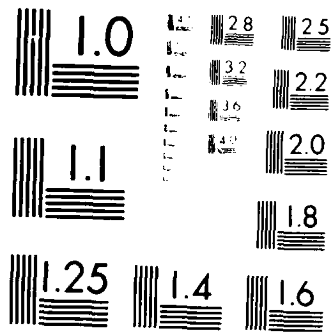
AD-A180 755 MECHANICAL PROPERTIES OF ALLUVIUM FROM NELLIS AIR FORCE 1/4
RANGE NEVADA; LUK..(U) TERRA TEK INC SALT LAKE CITY UT
J B WANGSGARD ET AL. 14 OCT 86 TR-86-76 DNA-TR-87-68

UNCLASSIFIED DNA001-83-C-0193 F/G 8/10 NL



MICROCOPY RESOLUTION TEST CHART

DNA-TR-87-68

MECHANICAL PROPERTIES OF ALLUVIUM FROM NELLIS AIR FORCE RANGE, NEVADA; LUKE BOMBING AND GUNNERY RANGE, ARIZONA; AND WHITE SANDS MISSILE RANGE, NEW MEXICO

J. B. Wangsgard, et al.
Terra Tek, Inc.
P.O. Box 8275
Salt Lake City, UT 84108-8275

14 October 1986

Technical Report

CONTRACT No. DNA 001-83-C-0193

Approved for public release;
distribution is unlimited.

THIS WORK WAS SPONSORED BY THE DEFENSE NUCLEAR AGENCY
UNDER RDT&E RMSS CODE B344084466 Y99QMXSB00002 H2590D

Prepared for
Director
Defense Nuclear Agency
Washington, DC 20305-1000

Destroy this report when it is no longer needed. Do not return to sender.

PLEASE NOTIFY THE DEFENSE NUCLEAR AGENCY ATTN: TITL, WASHINGTON, DC 20305 1000, IF YOUR ADDRESS IS INCORRECT, IF YOU WISH IT DELETED FROM THE DISTRIBUTION LIST, OR IF THE ADDRESSEE IS NO LONGER EMPLOYED BY YOUR ORGANIZATION.

DISTRIBUTION LIST UPDATE

This mailer is provided to enable DNA to maintain current distribution lists for reports. We would appreciate your providing the requested information.

- ☐ Add the individual listed to your distribution list.
- ☐ Delete the cited organization/individual.
- ☐ Change of address.

NAME: ______________________________

ORGANIZATION: ______________________________

OLD ADDRESS	CURRENT ADDRESS
______________	______________
______________	______________
______________	______________

TELEPHONE NUMBER: (   ) ______________________________

SUBJECT AREA(s) OF INTEREST:

______________ ______________

______________ ______________

______________ ______________

DNA OR OTHER GOVERNMENT CONTRACT NUMBER: ______________

CERTIFICATION OF NEED-TO-KNOW BY GOVERNMENT SPONSOR (if other than DNA):

SPONSORING ORGANIZATION: ______________________________

CONTRACTING OFFICER OR REPRESENTATIVE: ______________________________

SIGNATURE: ______________________________

CUT HERE AND RETURN

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY: N/A since Unclassified	3 DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited.
2b DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A since Unclassified	
4 PERFORMING ORGANIZATION REPORT NUMBER(S): TR 86-76	5 MONITORING ORGANIZATION REPORT NUMBER(S): DNA-TR-87-68
6a NAME OF PERFORMING ORGANIZATION: Terra Tek, Inc.; 6b OFFICE SYMBOL (if applicable):	7a NAME OF MONITORING ORGANIZATION: Director Defense Nuclear Agency
6c ADDRESS (City, State, and ZIP Code): P.O. Box 8275 Salt Lake City, Utah 84108-8275	7b ADDRESS (City, State, and ZIP Code): Washington, DC 20305-1000
8a NAME OF FUNDING/SPONSORING ORGANIZATION: ; 8b OFFICE SYMBOL (if applicable): SPST/Reed	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: DNA 001-83-C-0193
8c ADDRESS (City, State, and ZIP Code)	10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO
62715H	Y99QMXS	B	DH007937

11 TITLE (Include Security Classification)
MECHANICAL PROPERTIES OF ALLUVIUM FROM NELLIS AIR FORCE RANGE, NEVADA; LUKE BOMBING AND GUNNERY RANGE, ARIZONA; AND WHITE SANDS MISSILE RANGE, NEW MEXICO

12 PERSONAL AUTHOR(S)
Wangsgard, James B.; Smith, Redd H.; Borschel, Thomas F.; Klauber, William

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Technical	FROM 830527 TO 850731	861014	324

16 SUPPLEMENTARY NOTATION
This work was sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B344084466 Y99QMXSB00002 H2590D.

17 COSATI CODES

FIELD	GROUP	SUB-GROUP
8	7	
20	11	

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Mechanical Properties, Alluvium, Strain Path Tests, Uniaxial Strain, Triaxial Compression, Hydrostatic Compression

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Mechanical properties of four types of alluvium were evaluated under cycled hydrostatic compression, cycled uniaxial strain, triaxial compression, and controlled strain path loading conditions. The materials that were tested consisted of remolded soil similar to that found in portions of Nellis Air Force Range, Nevada, undisturbed soil core from the DIRECT COURSE test site at the White Sands Missile Range, New Mexico, and both remolded soil and undisturbed soil core from the CARES-Dry test site at the Luke Bombing and Gunnery Range, Arizona.

The remolded samples were compacted to a specified density of 1.9 g/cm^3 at a specified moisture content of 6 percent by weight. These samples consistently showed evidence of achieving full saturation at mean normal stresses of 100 to 200 MPa. The undisturbed CARES-Dry cores had lower moisture contents and the

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL: Sandra E. Young	22b TELEPHONE (Include Area Code): (202) 325-7042; 22c OFFICE SYMBOL: DNA/CSTI

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

or

Codes

Avail and/or Special

Dist

A-1

19. ABSTRACT (Continued)

undisturbed DIRECT COURSE cores had higher void ratios (indicated by lower sample densities) and neither material showed signs of achieving full saturation during the tests. Material behavior is therefore critically dependent on dry density and air voids within pressure regimes tested, and these factors should be evaluated before selection of material properties for modeling.

SUMMARY

The testing program revealed significant differences in the mechanical behavior between remolded and undisturbed alluvial soils. The specified remolding procedure resulted in higher water saturations, apparently causing the remolded specimens to become fully saturated at volumetric strains of 15-20%. Consequently, remolded strengths tended to be low, and post-saturation stiffnesses were high. The undisturbed specimens did not become fully saturated and therefore had larger strengths than the remolded materials, although they displayed greater variability.

The results of the cycled hydrostatic compression tests show notably different strain behavior between the remolded and undisturbed samples. Above 100 MPa confining pressure, the remolded samples consistently had much stiffer responses than the undisturbed samples. The remolded specimens had similar densities and moisture contents and likewise exhibited similar compaction properties through the entire range of confining stresses. The undisturbed specimens exhibited a wide range of volumetric strains during hydrostatic loading.

In the uniaxial strain tests, plots of the principal stress difference versus the mean normal stress indicate that the maximum stress difference is generally attained during the first cycle to 50 MPa confining pressure for the remolded samples, at which point full saturation apparently occurs. In all subsequent cycles, the loading slopes are generally shallower and the maximum stress differences are slightly smaller than the first loading. The fact that subsequent maximum stress differences are approximately the same level probably is an indication that the effective stress is unchanging once the sample reaches full saturation. The undisturbed samples typically have lower moisture contents and continually support larger deviatoric stresses during cycling to higher confining pressures.

Results of the triaxial compression tests indicate that the shear strength of the remolded alluvium is not significantly affected by an increase in the confining pressure after the samples approach full saturation and the effective stress becomes nearly constant.

The undisturbed samples are significantly stronger than the remolded samples. At confining stresses of 50 and 100 MPa, the yield strengths are quite comparable between the UDC and UWS samples, but at 200 MPa confining stress, there are major differences in the strengths. The single UDC sample tested at 200 MPa confining stress appears to be abnormally weak compared to the tests at 50 and 100 MPa, and the results should probably be discounted. The two UWS specimens tested at 200 MPa did not actually fail before the limits of the axial strain transducers were reached.

The strain path tests were performed in a relatively low stress regime compared to the conventional mechanical tests. Results of the strain path tests show an overall qualitative similarity among the four material types. Within the material groups, the stresses and strains were quantitatively similar as well. In general, the NV sand tends to have a stiffer response than the other three materials. Also, the UDC was found to be stiffer than the RDC and is similar to the UWS material.

Particular difficulties were encountered in completing strain paths 2A and 2B. In all type 2 strain path tests, samples encountered a region where it was not physically possible for the test materials to follow the strain paths since they required the specimens to rebound from unloading to a degree which they could not. This may indicate that the calculation of the strain path was based on an untenable material model, that the empirical data from field tests used for constructing the paths may have been subject to measurement error, or that these materials differ significantly from the materials on which the strain path was based.

CONVERSION FACTORS AND EQUIVALENT UNITS FOR METRIC (SI) TO U.S. CUSTOMARY UNITS OF MEASUREMENT

Multiply ⟶ by ⟶ To Get
To Get ⟵ by ⟵ Divide

meter	39.370	inch
Kilo pascal	0.145	pound-force/inch^2
Kilogram/meter^3	62.43×10^{-3}	pound-mass/inch^3

1 meter	= 1×10^3 millimeter	= 39.370 inch
1 Kilo pascal	= 1×10^{-3} Mega pascal	= 0.145 pound-force/inch^2
1 Kilogram/meter^3	= 1×10^{-3} gram/centimeter^3	= 62.43×10^{-3} pound-mass/inch^3

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION 1
INTRODUCTION

This report documents the results of a laboratory test program that was performed for the Defense Nuclear Agency under the general direction of the U.S. Army Engineer Waterways Experiment Station (WES). The purpose of the testing program was to assist in characterizing the mechanical properties of alluvium similar to that found at Nellis Air Force Range, Nevada, Luke Bombing and Gunnery Range, Arizona, and White Sands Missile Range, New Mexico.

Material descriptions, test procedures, and results are discussed in subsequent sections of this report. The testing program consisted of cycled hydrostatic compression, cycled uniaxial strain, triaxial compression, and strain path tests.

SECTION 2
MATERIAL DESCRIPTIONS

Four soil types, consisting of both processed soils and undisturbed core, were supplied by WES for the test program. The materials were: processed Nellis Baseline sand, which is a mixture of soils gathered throughout Ralston Valley, Nevada, that was blended by personnel of the WES Geomechanics Division such that its gradation would be similar to that encountered in the southeastern part of the valley within the Nellis Air Force Range; undisturbed soil cores from the DIRECT COURSE test site at the White Sands Missile Range; and both processed soils and undisturbed soil cores from the CARES-Dry test site at the Luke Bombing and Gunnery Range.

Soil classification and index tests were conducted by personnel of the WES Geotechnical Laboratory to determine grain size distributions, Atterberg limits, and specific gravities. Standard and modified compaction tests were also performed on the processed Nellis Baseline and CARES-Dry sand samples. This information was used by WES to classify the materials according to the Unified Soil Classification System (USCS).

The Nellis Baseline sand mixture is classified as a brown, well graded, clayey sand (SW-SC) that contains about 10 percent fines (clay and silt) by weight. The particle size distribution is presented in Figure 1. Standard Proctor compaction tests indicated a maximum dry density of about 1.87 g/cm^3 at an optimum water content of about 12 percent. Modified Proctor compaction test results indicated a maximum dry density of about 1.99 g/cm^3 at an optimum water content of about 9.1 percent.[1] The specific gravity and Atterberg limits are given in Table 1.

The processed CARES-Dry sand is classified as a brown clayey sand (SC) that contains about 33 percent fines by weight. The particle size distribution is shown in Figure 2. The results of the standard Proctor compaction tests indicated a maximum dry density of about 1.95 g/cm^3 at an optimum water content of about 11.6 percent, and modified Proctor compaction test results indicated a maximum dry density of about 2.11 g/cm^3 at an optimum water con-

1. J.D. Cargile, 1986, "Laboratory Test Results for Nellis Baseline Sand," Technical Report SL-86-15, September 1986, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, p. 10.

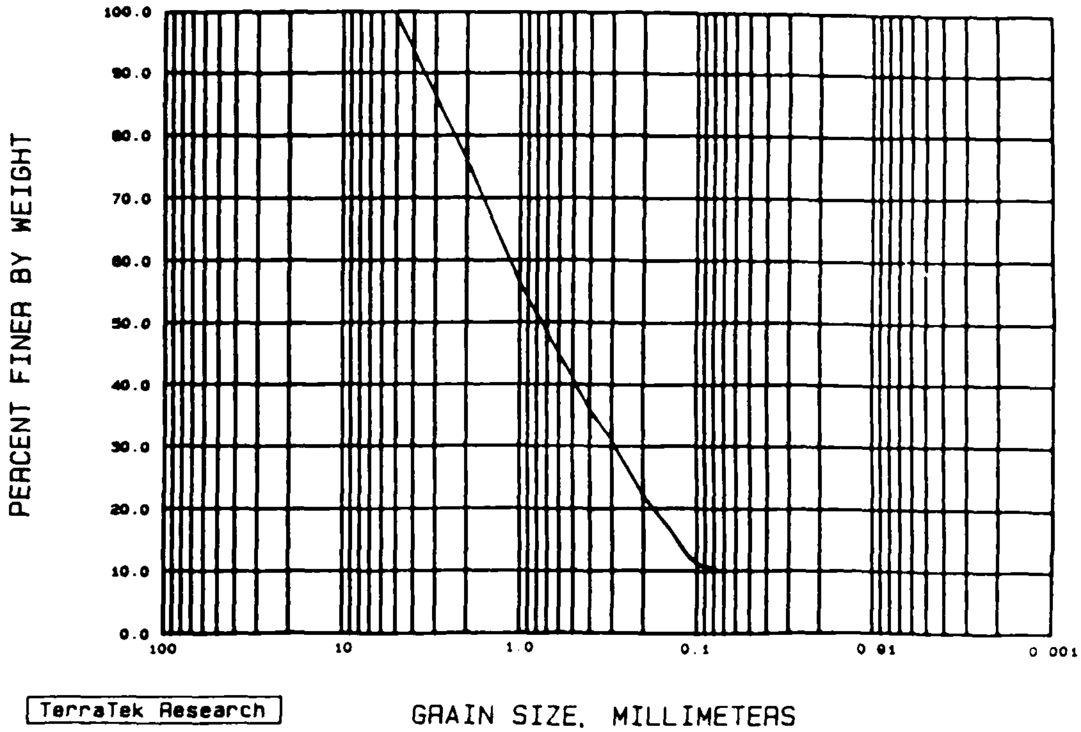


Figure 1. Particle size distribution curve for the processed Nellis Baseline sand, Nellis Air Force Range, Nevada (J.D. Cargile, 1986; reference 1).

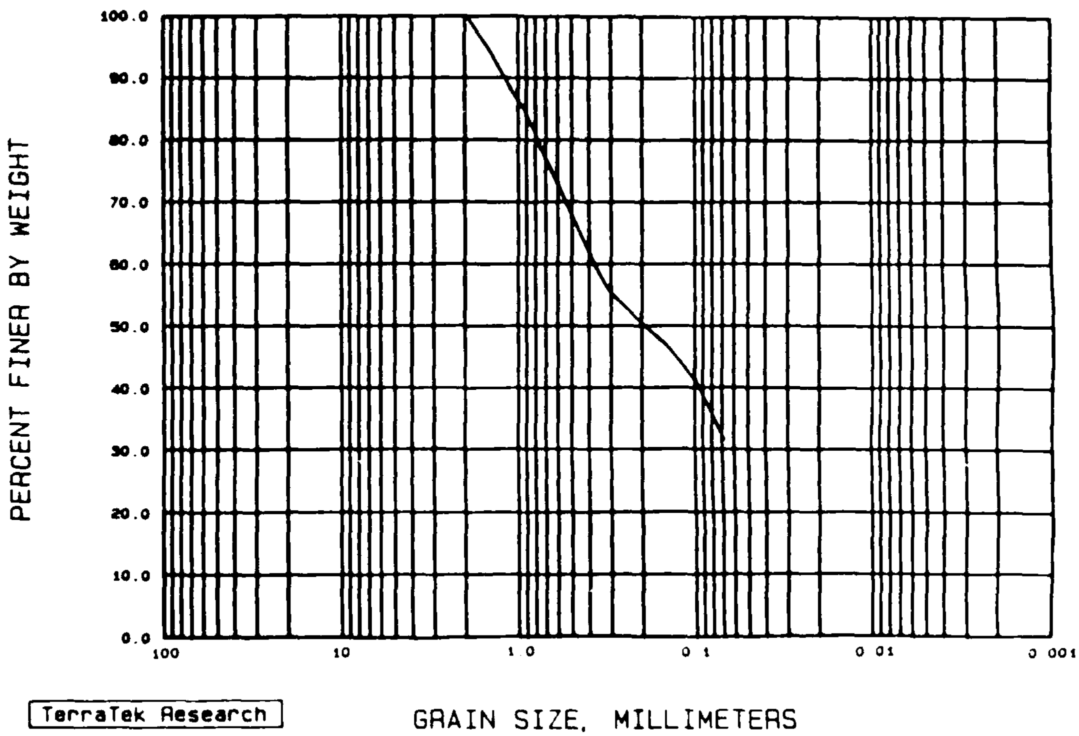


Figure 2. Particle size distribution curve for the processed CARES-Dry sand, Luke Bombing and Gunnery Range, Arizona (J.D. Cargile, 1986; reference 2).

Table 1. Specific gravity and Atterberg limits for remolded Nellis Baseline sand, remolded and undisturbed CARES-Dry sand and undisturbed DIRECT COURSE sand.

Sand	Specific Gravity of Soil Solids	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	USCS Classification
NV[1]	2.62	22	14	8	SW/SC
RDC[2]	2.67	36	17	19	SC
UDC[2]	2.68	37	16	21	SC
UWS[3]	2.81	27	16	11	SC/CL

NV - Remolded Nellis Baseline Sand
RDC - Remolded CARES-Dry Sand
UDC - Undisturbed CARES-Dry Sand
UWS - Undisturbed DIRECT COURSE Sand

---

1. Cargile, J.D., 1986, "Laboratory Test Results for Nellis Baseline Sand," Technical Report SL-86-15, September 1986, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, p. 10.
2. Cargile, J.D., 1986, "Geotechnical Investigation for the CARES-Dry Site: Laboratory Test Results," Technical Report LS-86-16, Report 2, September 1986, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, p. 18-19, 32.
3. Phillips, B.R., 1986, "Geotechnical Investigation for DIRECT COURSE and Related Events: Laboratory Test Results," Technical Report SL-86-18, Report 2, September 1986, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, p. 11-13.

tent of about 7.9 percent.[2] The specific gravity and Atterberg limits are given in Table 1.

The undisturbed CARES-Dry material is predominantly a variably cemented brown clayey sand (SC) with a trace of small gravel. The specific gravity and Atterberg limits are given in Table 1. Soil gradation data and in-situ water contents are given in Reference 2.

The DIRECT COURSE undisturbed soils are predominantly clayey sands and sandy clays interbedded with areas containing a gypsum cement. Water contents range from 1.3 to 35.0 percent. The variability in moisture content may be attributed to the stratified nature of the subsurface soils, with different layers being of different permeability and containing varying amounts of sand, clay and gypsum cement.[3] The particle size distribution is shown in Figure 3. The specific gravity and Atterberg limits are given in Table 1.

---

2. Cargile, J.D., 1986, "Geotechnical Investigation for the CARES-Dry Site: Laboratory Test Results," Technical Report SL-86-16, Report 2, September 1986, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, p. 7.
3. Phillips, B.R., 1986, "Geotechnical Investigation for DIRECT COURSE and Related Events: Laboratory Test Results," Tecnnical Report SL-86-18, Report 2, September 1986, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, p. 11-13.

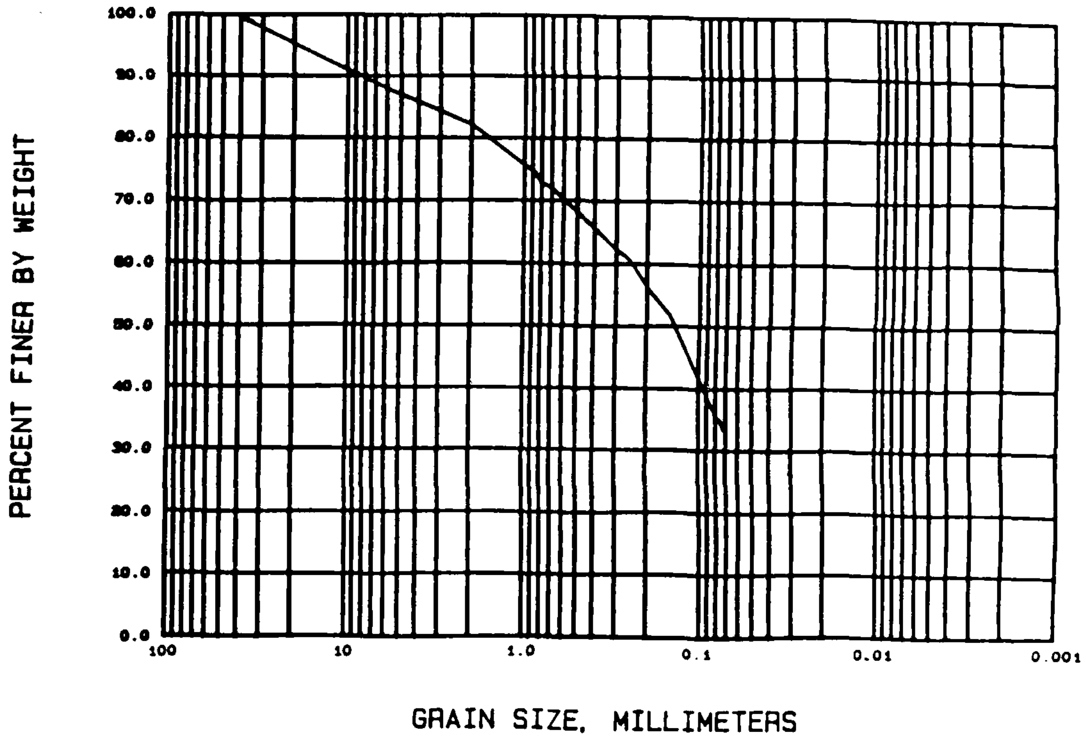


Figure 3. Particle size distribution curve for the undisturbed DIRECT COURSE sand, White Sands Missle Range, New Mexico (B.R. Phillips, 1986; reference 3).

SECTION 3
SAMPLE PREPARATION

Test materials were shipped to Terra Tek in numbered boxes. Undisturbed cores were capped with two wood disks ("packers") and jacketed in a thin (0.3 mm) rubber membrane. The cores were additionally wrapped in aluminum foil and labeled with a sample number. Appendix A outlines the handling procedures for the undisturbed cores. Appendix B lists the box, sample and boring numbers, and the depth interval of each undisturbed specimen used in the test program.

Processed soils for remolding were shipped in large batches and identified by the sampling site. Samples were prepared by forming the loose soils into right circular cylinders in a rigid wall consolidometer (uniaxial compaction). All remolded samples had a target density of 1.90 g/cm^3 and a target moisture content of 6% (by dry weight), specified by WES. Water was added to the soils as necessary during casting (remolding) to achieve the desired moisture content. Sample density was determined from geometrical and mass measurements, and moisture content was determined following testing as the ratio of the weight of water lost by oven drying to the dry weight of the sample. The initial density of the test specimen, post-test moisture content and the maximum axial stress applied during preparation is given on corresponding plots of the test data.

All of the remolded samples were lightly sprayed with a thin coating of a wax-like material to protect the integrity of the sample surface during handling. Some of the poorer undisturbed specimens with large voids along the surfaces were patched with epoxy to prevent jacket failure during testing.

SECTION 4
TEST PROCEDURES

4.1 GENERAL.

All conventional mechanical tests were performed with two servo controlled hydraulic test frames using a light refined oil inside the pressure vessel as a confining fluid. Strain path tests were performed with a computer controlled hydraulic test frame.

The prepared samples were placed between hardened steel endcaps and were jacketed with a double layer wrap of polyurethane to prevent intrusion of the confining fluid into the sample pore spaces. The total thickness of the polyurethane wrap was 0.5 mm. The specimens were then instrumented with strain transducers which measured axial strain and radial strain in two orthogonal directions. Specimens were deviatorically loaded with an axial strain rate of 1.25×10^{-4}/second for the conventional mechanical tests and at 1.00×10^{-5}/second for the strain path tests. Continuous analog data (X-Y recorder) and digital data were collected throughout each test.

4.2 CONVENTIONAL MECHANICAL TESTS.

Conventional mechanical tests consisted of cycled hydrostatic compression, cycled uniaxial strain, and triaxial compression tests. For the cycled hydrostatic compression tests, undrained specimens were subjected to increasing and decreasing confining pressure while changes in the specimens' height and diameter were measured. For most tests, the confining pressure was successively cycled to 50, 100, 200, and 400 MPa, and back to zero stress following each pressurization. The hydrostatic loading rate for all cycled tests was approximately 0.75 MPa/second.

In the cycled uniaxial strain tests, undrained specimens were cycled to zero stress from peak confining pressures of 50, 100, 200 and 400 MPa. An axial load was applied and constantly increased while the confining stress was continuously adjusted during the cycles to maintain zero radial strain. Five tests were cycled only to 200 MPa confining pressure due to the limits of the test frame pressure vessel, and one test was only cycled to 100 MPa due to a jacket failure. Those tests are indicated in Table 6 (see footnotes a and b).

Triaxial compression test specimens were tested undrained and subjected to a constant hydrostatic confining pressure of either 50, 100, 200, or 400

MPa. After the desired confining pressure was attained, a deviatoric stress was applied until either the specimen failed or the limits of the strain transducers were exceeded. Table 7 identifies the specimens that failed and those that reached the limits of the strain transducers (see footnotes a and b).

4.3 STRAIN PATH TESTS.

The strain paths were designed to represent strain histories experienced by soil elements undergoing explosion induced ground motions. The testing apparatus used for the strain path tests was a computer controlled triaxial loading frame with a pressure vessel limit of 100 MPa. A Digital Equipment Computer (DEC) PDP MINC 11 was interfaced to the triaxial loading frame for controlling the axial and confining pressures. During testing, the sample was strained by continuous adjustment of the confining and deviatoric stresses. The changes in stress required to go from one point on the strain path to the next were calculated by the computer using the generalized Hooke's law.

Two strain paths were investigated, identified as paths 2 and 3, each having two levels of strain magnitude. Path 2 represents deep far-field and path 3 deep near-field stress conditions in the vicinity of a buried high-explosive test. A total of four strain paths were followed and are identified as the 2A, 2B, 3A and 3C paths. Strain path 2B is a replicate of 2A but with twice the strain magnitudes. Similarly, strain path 3C is a replicate of 3A but with three times the strain magnitudes.

The strain paths were modeled by piece-wise continuous linear segments. Figures 4-7 show the piece-wise continuous segments forming strain paths 2A, 2B, 3A and 3C, respectively. Twenty-three segments were used to model strain paths 2A and 2B. Table 2 lists the axial and radial strains for each segment of paths 2A and 2B. Ten segments were used to model strain paths 3A and 3C, and Table 3 lists the axial and radial strains for each segment of strain paths 3A and 3C. In both tables, compression is positive and expansion is negative.

4.4 TEST MATRIX.

The number of tests that were performed and the nominal test specimen sizes for each material and test type are given in Table 4. The results of those tests are discussed in the following sections.

Table 2. Strain path 2 (deep far-field conditions) axial and radial strain segments (strains are given in millistrains*).

Segment	PATH 2A		PATH 2B	
	ε_A	ε_T	ε_A	ε_T
1	5.070	-0.04952	10.14	-0.09905
2	7.559	-0.22480	15.12	-0.4495
3	10.050	-0.40760	20.10	-0.8152
4	12.550	-0.62860	25.10	-1.2570
5	15.040	-0.93330	30.08	-1.867
6	17.540	-1.3450	35.08	-2.690
7	20.020	-1.8020	40.03	-3.604
8	22.510	-2.4190	45.01	-4.838
9	24.970	-3.280	49.94	-6.560
10	25.170	-3.349	50.33	-6.697
11	25.330	-3.448	50.67	-6.895
12	25.560	-3.539	51.11	-7.078
13	25.750	-3.699	51.50	-7.398
14	25.950	-3.935	51.89	-7.870
15	25.750	-4.194	51.50	-8.389
16	25.560	-4.331	51.11	-8.663
17	25.330	-4.499	50.67	-8.998
18	25.140	-4.590	50.28	-9.181
19	24.940	-4.690	49.89	-9.379
20	22.440	-5.787	44.88	-11.570
21	20.230	-6.495	40.45	-12.990
22	12.410	-2.541	24.81	-5.082
23	21.720	-7.265	43.45	-14.530

*Compression is positive, expansion is negative.
ε_A - Axial Strain
ε_T - Radial Strain

Table 3. Strain path 3 (deep near-field conditions) axial and radial strain segments (strains are given in millistrains*).

Segment	PATH 3A		PATH 3C	
	ε_A	ε_T	ε_A	ε_T
1	5.034	-0.2348	15.10	-0.7045
2	7.556	-0.3788	22.67	-1.136
3	10.03	-0.6667	30.09	-2.000
4	10.54	-0.7652	31.61	-2.295
5	11.03	-0.9773	33.10	-2.932
6	12.04	-1.886	36.11	-5.659
7	15.00	-4.992	44.99	-14.980
8	17.38	-7.311	52.13	-21.930
9	19.92	-10.000	59.75	-30.000
10	17.36	-8.667	52.07	-26.000

*Compression is positive, expansion is negative.

ε_A - Axial Strain

ε_T - Radial Strain

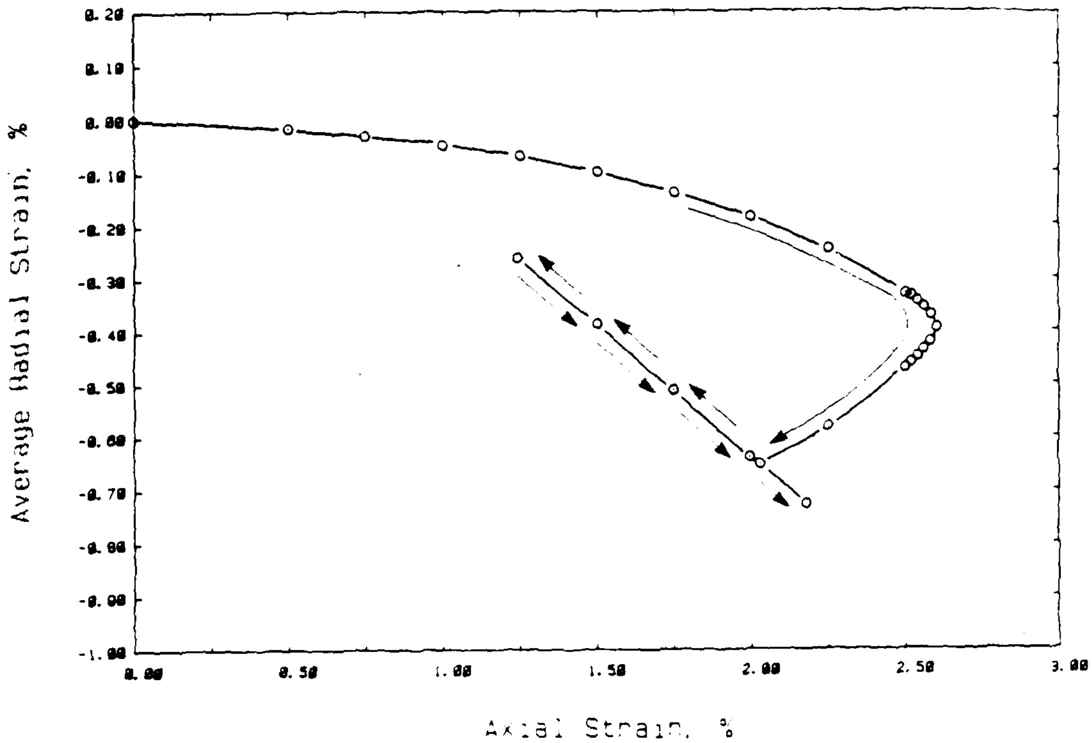


Figure 4. Strain path 2A.

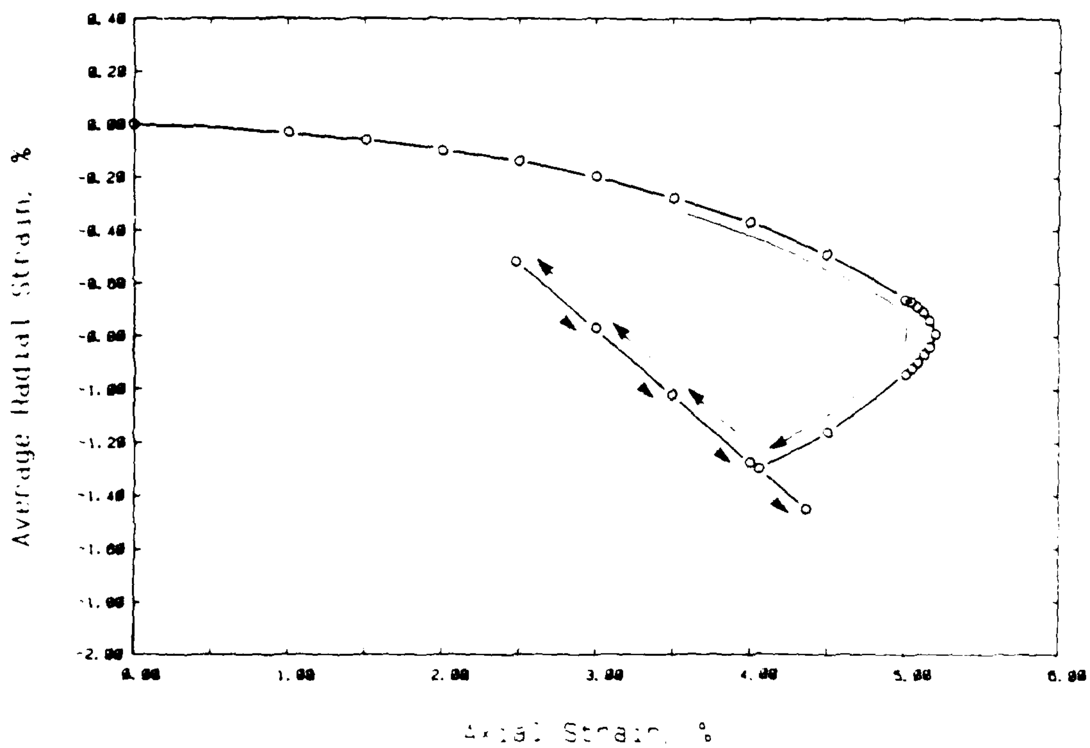


Figure 5. Strain path 2B.

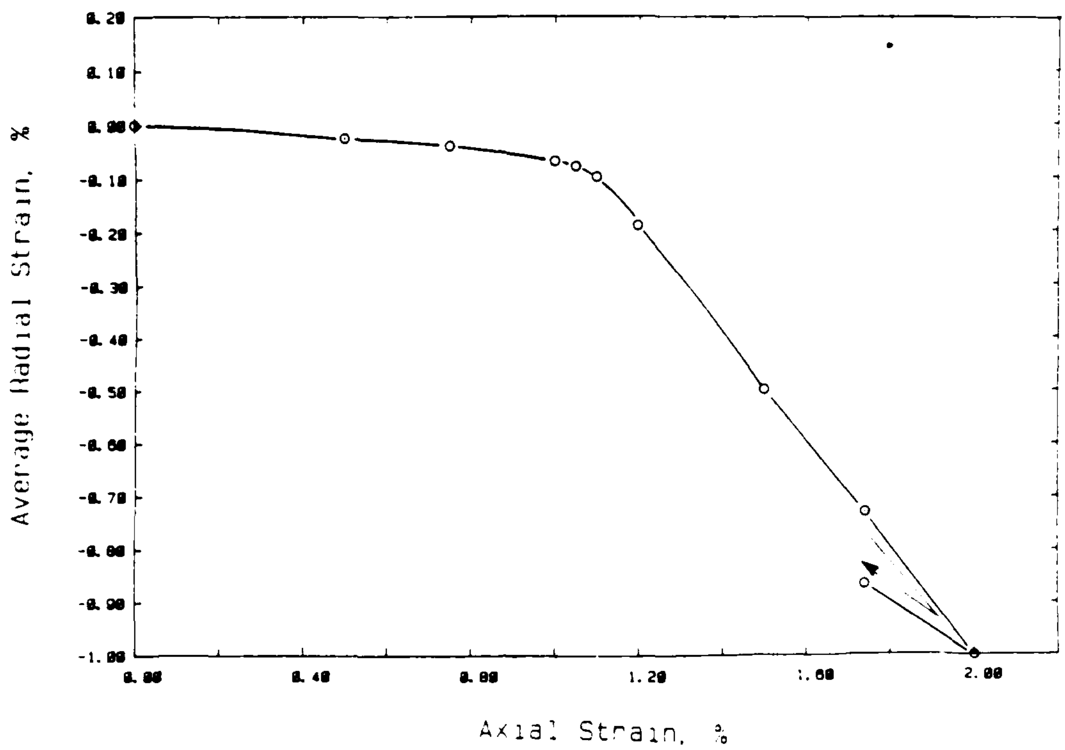


Figure 6. Strain path 3A.

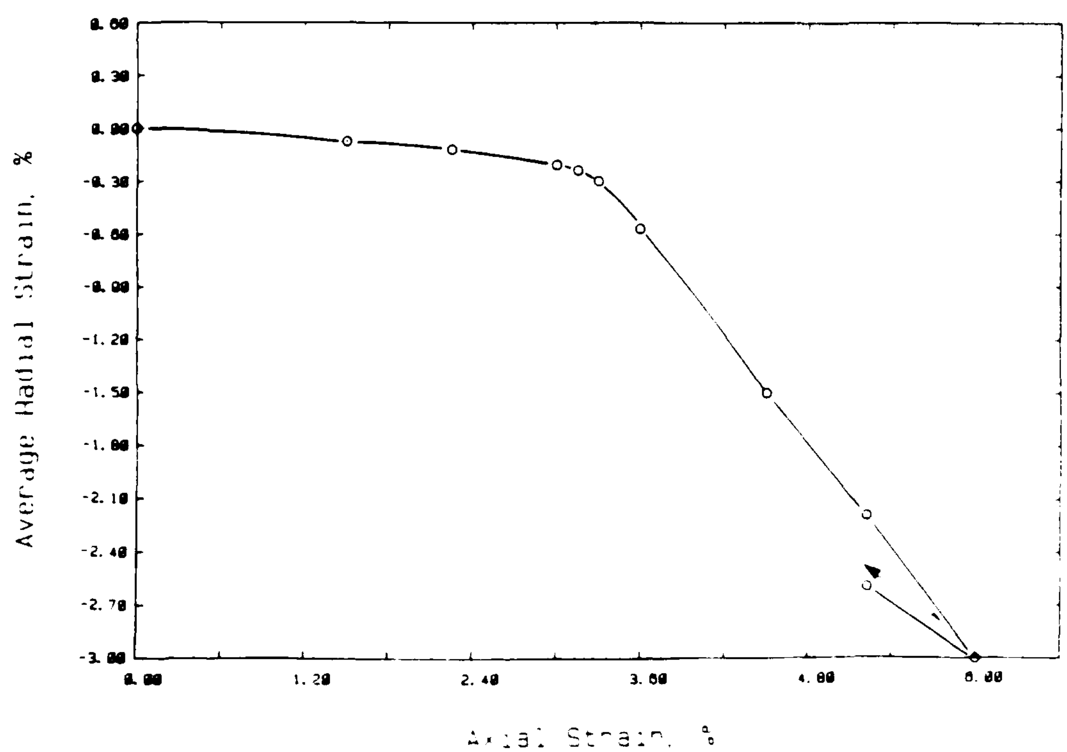


Figure 7. Strain path 3C.

Table 4. Number of tests performed and nominal test specimen size for the mechanical test program.

Test Material		TEST TYPE: Cycled Hydrostatic Compression	Cycled Uniaxial Strain	Triaxial Compression	Strain Path 2A	Strain Path 2B	Strain Path 3A	Strain Path 3C
Remolded Nellis Baseline Sand	No. of Tests	3	3	3	4	4	4	4
	Nominal Size (mm)	51 x 102	51 x 64	51 x 102	76 x 152	76 x 152	76 x 152	76 x 152
Remolded CARES-Dry Sand	No. of Tests	3	3	3	3	2	4	3
	Nominal Size (mm)	51 x 102	51 x 64	51 x 102	76 x 152	76 x 152	76 x 152	76 x 152
Undisturbed CARES-Dry Sand	No. of Tests	2	3	3	3	2	3	3
	Nominal Size (mm)	72 x 152	72 x 97	72 x 152	72 x 152	72 x 152	72 x 152	72 x 152
Undisturbed DIRECT COURSE Sand	No. of Tests	3	3	4	3	1	3	1
	Nominal Size (mm)	72 x 152	72 x 97	72 x 152	72 x 152	72 x 152	72 x 152	72 x 152

SECTION 5
TEST RESULTS

5.1 GENERAL.

The test results are illustrated by a series of data plots that follow the appendices and are discussed in subsequent sections. The conventional mechanical tests are discussed first, followed by the strain path tests.

5.2 CYCLED HYDROSTATIC COMPRESSION TESTS.

The cycled hydrostatic compression test data are presented as plots of confining pressure versus volumetric strain in Plates 1-11 and the results are summarized in Table 5. The volumetric strain was calculated from axial and radial strain data by the following equation:

$$\frac{dV}{V} = 2\varepsilon_T + \varepsilon_A - \varepsilon_T^2 - 2\varepsilon_T\varepsilon_A + \varepsilon_T^2\varepsilon_A$$

where: dV/V = fractional decrease in volume

ε_A = axial strain

ε_T = radial strain

Additionally, the slope of the confining pressure versus volumetric strain curve is the bulk modulus. The bulk moduli are reported in Table 6.

Plates 1-3, 4-6, 7-8 and 9-11 are the respective plots of the remolded Nellis Baseline sand (NV), remolded CARES-Dry sand (RDC), undisturbed CARES-Dry sand (UDC) and the undisturbed DIRECT COURSE sand (JWS). The numerical suffix attached to each material abbreviation in Table 5 identifies the corresponding plotted test data. Table 5 lists the test identification, sample material identification, the initial density, post-test moisture content, maximum volumetric strain attained during each cycle, and permanent compaction at the end of the cycle for each specimen. The permanent compaction is the level of volumetric strain that remains after the confining stress on the sample has been removed.

The most prominent feature of the cycled hydrostatic compression tests is the abrupt change of slope in the confining pressure-volumetric strain curve and the linear nature thereafter for both the remolded Nellis Baseline sand and the remolded CARES-Dry sand (Plates 1-6). The NV sand exhibits this

Table 5. Cycled Hydrostatic Compression Test Results.

Test I.D.	Specimen I.D. Box #	Sample #	Density (g/cm³)	Post-Test Moisture (%)	Maximum Volumetric Strain (%) 50 MPa	100 MPa	200 MPa	400 MPa	Permanent Compaction (%) 50 MPa	100 MPa	200 MPa	400 MPa
NV1	Remolded Sand		1.92	7.0	14.0	17.0	17.8	18.7	7.9	9.9	11.2	16.0
NV2	Remolded Sand		1.91	5.2	11.0	14.7	17.2	18.2	4.7	7.0	8.2	15.1
NV3	Remolded Sand		1.92	6.5	13.7	17.1	18.6	19.6	7.3	9.1	10.5	16.7
Mean Value					12.9	16.3	17.9	18.8	6.6	8.7	10.0	15.9
RDC1	Remolded Sand		1.91	5.9	18.4	19.7	20.1	20.9	12.2	13.5	14.1	18.4
RDC2	Remolded Sand		1.92	6.0	18.7	18.7	19.1	19.2	12.0	12.6	13.2	18.0
RDC3	Remolded Sand		1.92	5.3	18.6	20.5	20.8	21.6	12.0	13.9	15.3	16.8
Mean Value					18.6	19.6	20.0	20.6	12.1	13.3	14.2	17.7
UDC1	19	5	2.25	1.0	10.5	13.5	16.1	18.6	8.5	10.6	12.8	14.7
UDC2	19	2	2.27	0.5	7.4	9.7	11.9	14.1	5.9	8.1	9.6	9.8
Mean Value					8.9	11.6	14.0	16.3	7.2	9.4	11.2	12.3
UWS1	4	2	*	1.7	13.5	17.4	21.3	24.5	11.2	15.0	18.1	20.6
UWS2	4	1	*	3.5	17.6	22.0	26.0	29.0	15.4	19.4	22.0	22.5
UWS3	4	4	*	2.7	16.9	19.4	23.4	*	14.8	17.2	21.6	*
Mean Value					16.0	19.6	23.6	26.7	13.8	17.2	20.6	21.6

*Data Unavailable

NV - Remolded Nellis Valley Baseline Sand, Nellis Air Force Range, Nevada

RDC - Remolded CARES-Dry Sand, Luke Bombing and Gunnery Range, Arizona

UDC - Undisturbed CARES-Dry Sand, Luke Bombing and Gunnery Range, Arizona

UWS - Undisturbed DIRECT COURSE Sand, White Sands Missile Range, New Mexico

behavior at a volumetric strain of approximately 17-18% and the RDC at approximately 18-20%. The slope of the linear portion of the curve is similar for both materials. This type of strain response suggests that the change in slope occurs at the point where most of the intergranular air voids have been reduced in size by compaction and the sample has become fully saturated. The confining stress is thereafter supported not only by the grain strength, but also by the pore fluid pressure. The magnitude and linearity of the slope tends to support this interpretation. Similar behavior is seen in the hydrostatic portion of the triaxial compression tests.

The abrupt transition in the volumetric strain response is not observed for the undisturbed CARES-Dry and DIRECT COURSE materials. Instead, a continuous change in slope is observed, even as peak confining stresses are approached. The difference in behavior may be due to the lower moisture content of the undisturbed CARES-Dry specimens and the higher void ratio of the undisturbed White Sands specimens, and neither of the undisturbed materials appear to have reached full saturation.

RDC and UWS sands have the largest volumetric strains and permanent compactions. Volumetric strains were the smallest for UDC, which is related to the higher dry density. Both of the remolded material types exhibit less variability than the undisturbed core. The group averages of the maximum volumetric strains and permanent compactions attained during each cycle were computed for the four material types and are reported in Table 5 as the mean value. The mean values are plotted against confining pressures in Figures 8-9. The plots illustrate the general compressive properties of the four material types and indicate that for all four materials the void spaces compress rapidly from approximately 0 to 100 MPa confining stress, probably becoming filled with pore fluid or rearranged and/or crushed granular particles. As the hydrostatic load is increased from 100 to 400 MPa, the matrix becomes more tightly packed and there is an increasingly stiffer response. The remolded specimens are stiffer than the undisturbed specimens at higher confining stresses due to saturation. Permanent compactions are nearly as large as the volumetric strains at each cycle, indicating that the granular framework is progressively destroyed or inelastically altered.

Some anomalous behavior is observed in the hydrostatic compression test UWS3 (Plate 11). During the cycle from 300 MPa to zero stress and in the 400 MPa cycle, the confining pressure-volumetric strain curve shows unexpected

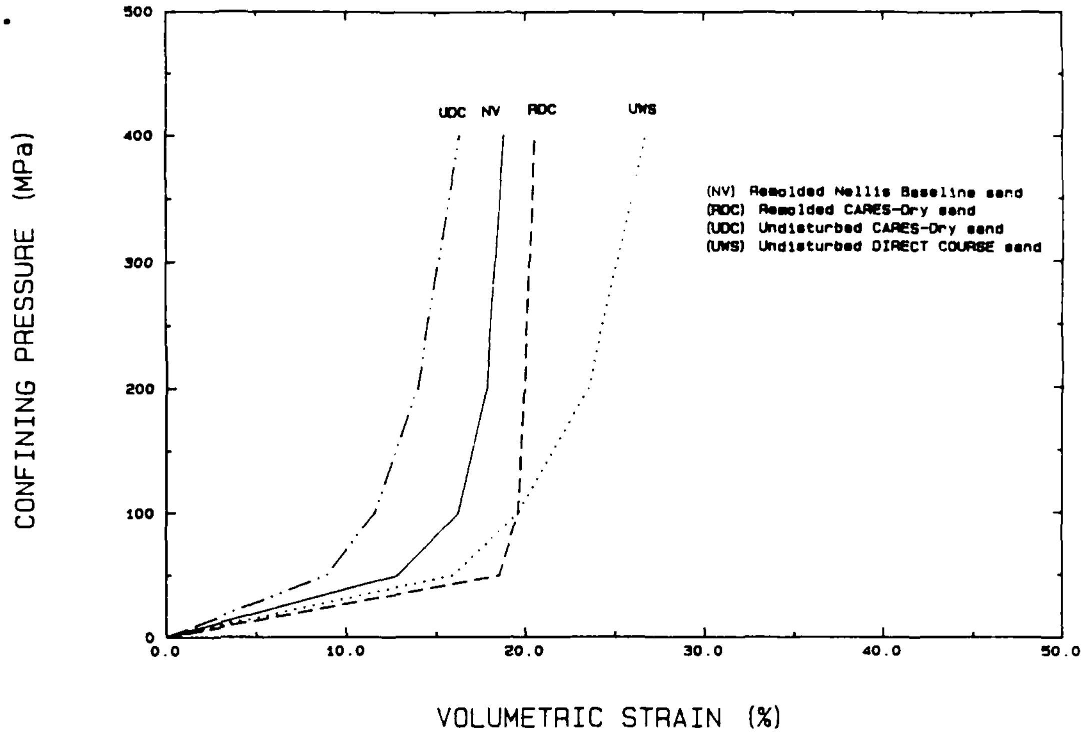


Figure 8. Mean maximum volumetric strain from cycled hydrostatic compression data in Table 5.

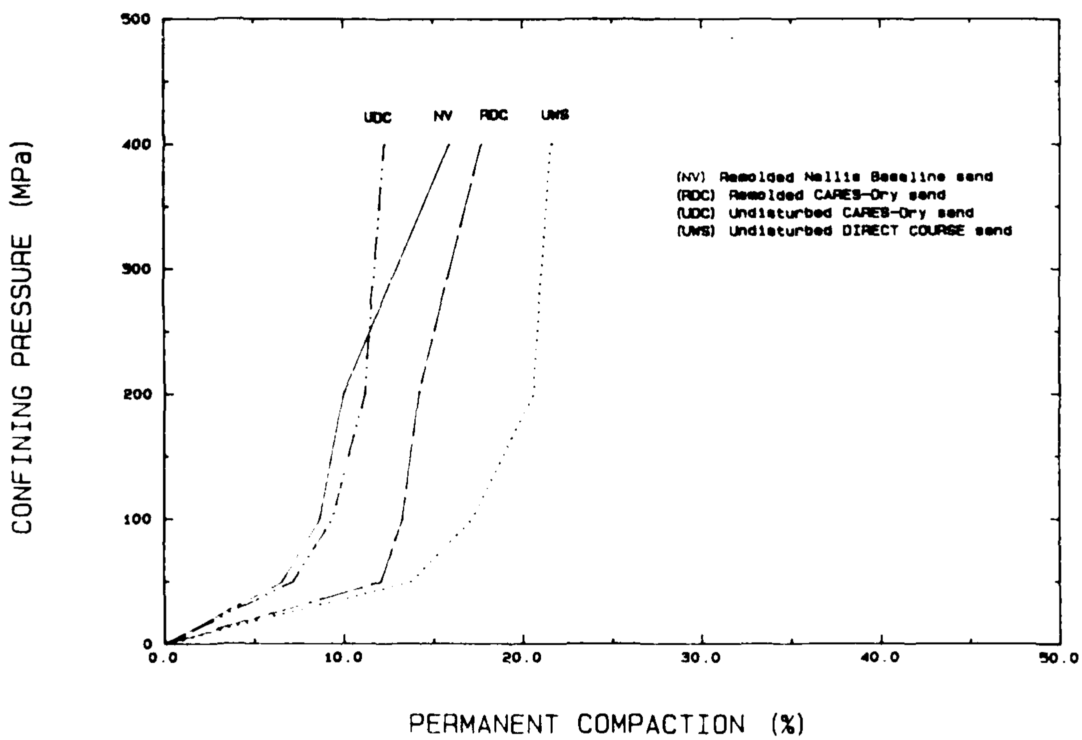


Figure 9. Mean permanent compaction from cycled hydrostatic compression data in Table 5.

strain reversals. At several points on the curve, the volumetric strain increases as the confining stress decreases, and on the 400 MPa cycle, the volumetric strain decreases as the confining stress increases. This behavior may be attributable to placement of the radial strain transducers on locally deforming areas of the specimen where large grains of gravel may have shifted under the transducer contacts, causing irregular strain measurements. Alternatively, the axial strain transducers may have been affected by skewed endcap deflection caused by irregular specimen deformation.

5.3 CYCLED UNIAXIAL STRAIN TESTS.

The cycled uniaxial strain test results are summarized in Table 6, and for each test the data are graphically illustrated by four plots (Plates 12-59). The four plots present axial stress versus axial strain, principal stress difference versus principal strain difference, principal stress difference versus mean normal stress, and confining pressure versus the volumetric strain. Plates 12-23, 24-35, 36-47 and 48-59 are the respective plots of the test data for the NV, RDC, UDC and UWS materials. The numerical suffix attached to the material abbreviation in Table 6 identifies the corresponding plotted test data.

Table 6 lists the test specimen, the initial density, post-test moisture content, the constrained secant moduli at 50, 100, 200, 300 and 400 MPa axial stress, the equivalent shear moduli at 20 and 40 MPa principal stress difference for the NV samples, at 20 MPa for the RDC samples, and at 50 and 100 MPa for the undisturbed samples, the stress ratio, K_O, and Poisson's ratio, ν. K_O and ν were calculated for the first cycle to 50 MPa confining pressure.

The constrained modulus, σ_1/ε_A, was calculated from the slope of the secant on the axial stress versus axial strain plot. An equivalent shear modulus for uniaxial strain conditions, $G = 1/2\ \sigma_d/\varepsilon_A$, was calculated from the plot of principal stress difference versus principal strain difference where the principal strain difference is $\varepsilon_A - \bar{\varepsilon}_T$ and $\bar{\varepsilon}_T = 0$. K_O, the ratio of horizontal to vertical stress, and Poisson's ratio, ν, were calculated from the plot of principal stress difference versus mean normal stress using the following equations:

Table 6. Uniaxial Strain Test Results.

Test I.D.	Specimen I.D. Box #	Specimen I.D. Sample #	Initial Density (g/cm^3)	Post-Test Moisture (%)	Constrained Modulus (MPa) at σ_1 (MPa) 50	100	200	300	400	Shear Modulus (MPa) at $\sigma_1-\sigma_3$ (MPa) 20	40	K_o	Poisson's Ratio
NV1	Remolded Sand		1.90	6.9	960	53310	53310	53310	53310	170	1780	0.43	0.30
NV2	Remolded Sand		1.90	7.8	980	49240	49240	49240	49240	190	1050	0.42	0.30
NV3	Remolded Sand		1.93	6.7	1150	4160	27590	27590	27590	170	1250	0.39	0.28
RDC1	Remolded Sand		1.90	*	960	57790	57790	57790	57790	230	*	0.50	0.33
RDC2	Remolded Sand		1.90	7.3	740	33520	33520	33520	33520	190	*	0.51	0.34
RDC3	Remolded Sand		1.90	5.8	1120	53030	53030	53030	53030	300	*	0.52	0.34
										50	100		
UDC1[a]	21	1	1.84	1.0	1260	2510	6010	*	*	720	1480	0.46	0.32
UDC2[b]	21	2	1.61	1.5	790	1210	3020	6970	*	420	820	*	*
UDC3[b]	21	3	1.65	1.3	990	1660	4350	8190	9380	230	450	0.50	0.33
UWS1[b]	5	2	1.80	3.5	790	1450	2720	5310	6570	310	560	0.54	0.35
UWS2[b]	5	3	1.64	3.9	800	1290	2920	9450	*	330	750	0.52	0.34
UWS3[b]	5	4	1.64	4.2	750	1920	4790	9650	*	430	1530	0.63	0.39

*Data Unavailable

a - Cycled to 100 MPa maximum confining pressure (jacket leak on 200 MPa cycle).

b - Cycled to 200 MPa maximum confining pressure (pressure vessel limits).

NV - Remolded Nellis Valley Baseline Sand, Nellis Air Force Range, Nevada

RDC - Remolded CARES-Dry Sand, Luke Bombing and Gunnery Range, Arizona

UDC - Undisturbed CARES-Dry Sand, Luke Bombing and Gunnery Range, Arizona

UWS - Undisturbed DIRECT COURSE Sand, White Sands Missile Range, New Mexico

Principal Stress Difference	$\sigma_d = \sigma_1 - \sigma_3$
Mean Normal Stress	$\sigma_m = (\sigma_1 + 2\sigma_3)/3$
Slope of Curve	$x = \sigma_d/\sigma_m$
Ratio of Stress	$K_o = \sigma_3/\sigma_1 = (3-x)/(3+2x)$
Poisson's Ratio	$\nu = K_o/(K_o+1)$

An equivalent bulk modulus for uniaxial strain conditions, K, was calculated using the following equation:

Bulk Modulus $\quad K = \sigma_m/\varepsilon_A = (\sigma_d/\varepsilon_A)/(\sigma_d/\sigma_m)$

The bulk moduli are reported at the end of Test Results section in Table 8.

The constrained moduli are larger and more uniform for the remolded specimens than for the undisturbed specimens. At 50 MPa, the respective averages and standard deviations are 1030 MPa and 104 for NV, 940 MPa and 191 for RDC, 1010 MPa and 236 for UDC, and 780 MPa and 26 for UWS. For axial stress above 50 MPa, the remolded samples behaved similarly. The constrained moduli are uniform from 100 to 400 MPa and the respective averages are 43.4 and 48.1 GPa and the standard deviations are 14 and 13 GPa for NV and RDC.

The undisturbed samples have greater variation. The averages for 100 MPa are 1800 and 1560 MPa with standard deviations of 660 and 330 for UDC and UWS, respectively. For 200 MPa, the averages and standard deviations are 4460 MPa and 1500 for UDC and 3480 MPa and 1140 for UDC. The averages for 300 MPa are 7490 MPa with a standard deviation of 990 MPa for UDC and 3140 MPa with a standard deviation of 2450 MPa for UWS. One specimen from UDC (UDC1, Table 6) did not reach 300 MPa. There are no averages for the UDC and UWS samples at 400 MPa.

The shear moduli are uniform within each material group. The shear moduli for the NV samples were calculated at 20 and 40 MPa principal stress difference and at 20 MPa for the RDC samples. At 20 MPa, the NV material has an average of 177 MPa with a standard deviation of 11.5, and at 40 MPa, the average is 1360 MPa with a standard deviation of 377.2. The average value at 20 MPa for RDC is 240 MPa with a standard deviation of 55.7. The averages for the undisturbed specimens at 50 MPa are 457 and 357 MPa with standard deviations of 247 and 64.3 for UDC and UWS, respectively. The respective averages for UDC and UWS at 100 MPa are 917 and 947 MPa with standard deviations of 521.8 and 514 MPa.

K_o, the ratio of horizontal to vertical stress, was determined as previously explained, for the first uniaxial strain cycle to 50 MPa confining pressure. The averages and standard deviations of K_o are 0.41 and 0.021, 0.51 and 0.01, 0.48 and 0.028, and 0.56 and 0.056 for NV, RDC, UDC and UWS, respectively.

The average values for Poisson's ratio are 0.29, 0.34, 0.32, and 0.36 with standard deviations of 0.011, 0.006, 0.007 and 0.026 for NV, RDC, UDC and UWS, respectively.

Examination of the stress difference versus mean normal stress plots reveals marked differences in stress difference levels achieved by the undisturbed and remolded test specimens. The deviatoric stresses are larger, although more variable, in the undisturbed samples. This same trend was observed in the triaxial compression tests, and is consistent with the interpretation that the remolded samples became fully saturated during compression.

Uniaxial strain test No. RDC2 indicates a negative stress in the axial stress-axial strain plot (Plate 28) which may be construed as a negative deviatoric stress (extensional stress state). The test equipment used for the uniaxial strain tests is not capable of producing extensional forces, and it is suspected that a voltage offset in the deviatoric load transducer occurred during the test. The voltage offset was likely due to technician error, since subsequent load transducer calibrations and test data did not reveal any further measurement errors.

5.4 TRIAXIAL COMPRESSION TESTS.

The triaxial compression test data are presented graphically by two plots for each test in Plates 60-85, and the results are summarized in Table 7. The first plot is for the data acquired during the hydrostatic loading portion of the test, and displays the confining pressure versus the axial, radial and the volumetric strain. The second plot is for the data acquired during deviatoric loading, and shows stress difference versus the average axial and radial strains.

Plates 60-65, 66-71, 72-77 and 78-85 are the respective plots of the NV, RDC, UDC and UWS triaxial compression test data. The numerical suffix attached to the material abbreviation in Table 7 identifies the corresponding plotted test data. Table 7 lists the initial sample density, post-test moisture content, confining stress, maximum volumetric strain during hydrostatic com-

Table 7. Triaxial Compression Test Results.

Test I.D.	Specimen I.D. Box #	Specimen I.D. Sample #	Density (g/cm^3)	Post-Test Moisture (%)	Confining Stress (MPa)	Hydrostatic Max. Vol. Strain (%)	Maximum Deviator Stress (MPa)		ε_A at Max. Dev. Stress (%)	Young's Modulus (MPa)	Strain Ratio $\varepsilon_T/\varepsilon_A$
NV1	Remolded Sand		1.91	6.0	200	18.9	89.1	F[a]	9.7	4096.5	0.31
NV2	Remolded Sand		1.92	5.8	100	16.5	72.2	F	9.2	2662.11	0.25
NV3	Remolded Sand		1.91	6.1	400	18.9	82.5	L[b]	13.4	5131.0	0.38
RDC1	Remolded Sand		1.92	5.3	200	20.5	28.4	F	9.7	2531.0	0.48
RDC2	Remolded Sand		1.91	5.7	100	20.7	31.6	F	10.0	2420.7	0.43
RDC3	Remolded Sand		1.92	5.4	400	18.6	28.4	F	10.2	1937.9	0.40
UDC1	22	3	1.81	4.1	200	18.9	132.0	F	24.9	4634.5	0.36
UDC2	22	4	1.67	2.7	50	19.5	94.2	F	19.8	793.1	0.20
UDC3	18	5	1.89	*	100	16.0	166.7	F	23.1	3027.6	0.19
UWS1	23	5	1.63	5.8	100	26.8	166.7	F	20.0	1544.8	0.33
UWS2	22	2	1.56	5.9	200	29.6	303.8	F	11.5	1965.5	0.21
UWS3	23	6	1.44	7.1	200	30.9	250.6	F	12.1	2600.0	0.36
UWS4	5	5	1.72	3.57	50	16.8	104.5	L	28.1	662.1	0.23

*Data Unavailable

a - Test terminated by specimen failure at maximum deviator stress (F).

b - Test terminated when limits of strain transducers were exceeded (L).

NV - *Remolded Nellis Valley Baseline Sand*, *Nellis Air Force Range*, Nevada

RDC - Remolded CARES-Dry Sand, Luke Bombing and Gunnery R[illegible], Arizona

UDC - Undisturbed CARES-Dry Sand, Luke Bombing and Gunnery Range, Arizona

UWS - Undisturbed DIRECT COURSE Sand, White Sands Missile Range, New Mexico

pression, maximum deviatoric stress at failure, secant Young's modulus, and the strain ratio, $\varepsilon_T/\varepsilon_A$. The maximum deviatoric stress was taken to be the peak stress difference at failure, or when the limits of the transducers were reached. The bulk moduli obtained from the hydrostatic portion of each test are given in Table 8 following this section.

The maximum volumetric strains were obtained from the peak hydrostatic load portion of each test and are similar to those obtained from the cycled hydrostatic compression tests at similar confining pressures. Deviatoric failure stresses, Young's moduli and the strain ratios were determined from the triaxial portion of the test. Young's modulus is calculated from the secant in the first linear portion of the stress difference versus axial strain curve plotted from the triaxial compression portion of the test. The average values for Young's modulus are 3963, 2296, 2818, and 1693 MPa with standard deviations of 1239, 315, 1929 and 812 MPa for NV, RDC, UDC and UWS, respectively.

The strain ratio was calculated using the corresponding linear portion of the stress difference versus radial strain and axial strain curves. The average values and standard deviations for the material groups are: 0.31 and 0.065 for NV, 0.44 and 0.040 for RDC, 0.25 and 0.095 for UDC, and 0.28 and 0.074 for UWS.

The shear strength of the remolded soils does not appear to be significantly affected by an increase in confining pressure once the confining stress region that corresponds with the linear portion of the hydrostatic stress curve has been reached. This is consistent with full saturation of the pore space and subsequent behavior according to the effective stress law. In the higher stress-strain regions, the effective stress should be increasing much more slowly than total stress, and the shear strength should therefore be only minimally dependent on the confining pressure.

The undisturbed specimens tend to have a higher shear strength than the remolded specimens, but they also exhibit greater variability.

5.5 SUMMARY OF BULK MODULI COMPILED FROM ROUTINE MECHANICAL TESTS.

The bulk moduli calculated from the routine mechanical tests are compiled in Table 8. The bulk moduli increased as the confining pressure increased. Some samples in the RDC group reached peak moduli values at 100 MPa confining pressure, while most other samples peaked at 200 MPa. The bulk moduli for the

Table 8. Summary of Bulk Moduli (MPa) Compiled from Routine Mechanical Tests.

Material Type	Test Type	Confining Pressure											
		50 MPa			100 MPa			200 MPa			400 MPa		
NV	Hydrostatic	760	585	650	2170	2085	2220	22570	25280	27000	23065	25280	27000
	Triaxial	780	770	770	2000	1820	1640	15840	--	22760	--	--	20895
	Uniaxial	385	410	330									
RDC	Hydrostatic	1050	2000	620	20000	20000	2940	22900	33265	30680	27900	33265	30680
	Triaxial	860	1250	1040	25490	--	32275	25490	--	32275	--	--	32275
	Uniaxial	615	525	855									
UDC	Hydrostatic	820	960	--	1890	2625	--	4170	5550	--	9515	11450	--
	Triaxial	1285	570	1110	2780	--	2940	20145	--	--	--	--	--
	Uniaxial	1725	715	840									
UWS	Hydrostatic	310	540	625	1370	1220	1750	3170	2985	2740	7690	9310	--
	Triaxial*	705	850	890	1640	2170	2170	--	3855	4550	--	--	--
	Uniaxial	925	960	1740									

*Test UWS4 from the triaxial test was not included.

NV - Remolded Nellis Valley Baseline Sand, Nellis Air Force Range Nevada
RDC - Remolded CARES-Dry Sand, Luke Bombing and Gunnery Range, Arizona
UDC - Undisturbed CARES-Dry Sand, Luke Bombing and Gunnery Range, Arizona
UWS - Undisturbed DIRECT COURSE Sand, White Sands Missile Range, New Mexico

undisturbed samples remained quite low at high confining pressure compared to the remolded samples.

5.6 STRAIN PATH TESTS.

Strain path data are graphically presented by four plots for each test (Plates 86-273), which show radial versus axial strain, principal stress difference versus mean normal stress, principal stress difference versus principal strain difference, and volumetric strain versus principal strain difference. Plates 86-149, 150-197, 198-241, and 242-273 are the respective plots of the NV, RDC, UDC and UWS strain path data. Table 9 lists the sample identification, density and post-test moisture contents for the strain path test specimens.

The first plot mentioned, radial versus axial strain, shows the strain path actually followed by the sample. The dashed line in the radial versus axial strain plots is the intended strain path and the solid line indicates the path that was actually followed. The initial hydrostatic preload is not shown on the plot and the zero strain point was taken to be the start of the strain path test. The remaining plots include data from the stress-strain response of the sample during the hydrostatic preload. The beginning of the hydrostatic preload is marked as point A. The end of the preload and the beginning of the strain path loading is denoted as point B.

Hydrostatic preloads were generally between 5.8 MPa and 7.0 MPa. The preload stresses were applied to create an initial volumetric strain in order to store enough strain energy to allow the strain paths to be followed into the region of radial strain reversal. Larger preload stresses were applied to specimens that initially had small volumetric strain responses.

Despite the initial hydrostatic preloads, strain paths 2A and 2B could not be followed to completion. The principal stress difference or confining pressure always became zero before the strain path traverse reached the point of radial strain reversal. There was not enough elastic strain energy to allow the specimen to rebound sufficiently.[4] Completion of the strain path traverse would have required the specimens to be subjected to tensile stresses. Fewer difficulties were encountered in following strain paths 3A and 3C;

---

4. Akers, S.A.; "Axisymmetric Strain-Path and Stress-Path Tests on CARES-Dry Clayey Sand," Technical Report SL-86-23, September 1986, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, p. 40.

Table 9. Identification, density and moisture contents for strain path test specimens.

Strain Path	Test I.D.	Specimen I.D. Box #	Sample #	Density (g/cm^3)	Post-Test Moisture (%)
2A	NV1	Remolded Sand		1.90	6.12
	NV2			1.90	5.94
	NV3			1.90	6.25
	NV4			1.90	5.35
2B	NV1	Remolded Sand		1.90	5.86
	NV2			1.90	5.43
	NV3			1.90	5.33
	NV4			1.90	4.93
3A	NV1	Remolded Sand		1.90	6.61
	NV2			1.90	5.65
	NV3			1.92	5.88
	NV4			1.91	5.90
3C	NV1	Remolded Sand		1.91	5.87
	NV2			1.90	6.30
	NV3			1.91	6.27
	NV4			1.90	5.25
2A	RDC1	Remolded Sand		1.91	5.80
	RDC2			1.91	5.53
	RDC3			1.91	5.96
2B	RDC1	Remolded Sand		1.92	1.90
	RDC2			1.90	5.17
3A	RDC1	Remolded Sand		1.90	5.27
	RDC2			1.90	5.38
	RDC3			1.90	5.45
	RDC4			1.90	5.38
3C	RDC1	Remolded Sand		1.90	5.39
	RDC2			1.90	5.63
	RDC3			1.88	5.49

NV - Remolded Nellis Valley Baseline Sand, Nellis Air Force Range, Nevada

RDC - Remolded CARES-Dry Sand, Luke Bombing and Gunnery Range, Arizona

Table 9. Identification, density and moisture contents for strain path test specimens (continued).

Strain Path	Test I.D.	Specimen I.D.		Density (g/cm^3)	Post-Test Moisture (%)
		Box #	Sample #		
2A	UDC1	15	2	1.76	0.91
	UDC2	17	5	1.71	1.00
	UDC3	15	4	1.84	0.85
2B	UDC1	16	4	1.81	2.07
	UDC2	18	1	1.92	3.55
3A	UDC1	17	1	1.89	1.92
	UDC2	17	2	1.96	1.45
	UDC3	17	4	1.95	0.96
3C	UDC1	15	1	1.94	2.16
	UDC2	15	3	1.96	1.19
	UDC3	16	2	1.82	0.63
2A	UWS1	1	1	1.99	3.62
	UWS2	1	3	1.68	12.93
	UWS3	2	1	*	*
2B	UWS1	6	5	1.90	9.70
3A	UWS1	2	4	1.91	6.58
	UWS2	2	3	1.79	8.26
	UWS3	3	3	1.72	12.37
3C	UWS1	6	1	1.96	5.64

*Data unavailable

UDC - Undisturbed CARES-Dry Sand, Luke Bombing and Gunnery Range, Arizona.

UWS - Undisturbed DIRECT COURSE Sand, White Sands Missile Range, New Mexico.

only three tests could not be followed to completion. Tests NV1 3C, UDC1 3A, and UWS1 3C were the only type 3 strain path tests that were not completely traversed.

Results of the strain path tests show a qualitative consistency among the four material types, and the magnitudes of the stresses and strains are typically similar from sample to sample within each material group. The Nellis Baseline sand displays the stiffest response, requiring greater deviatoric loads to follow the desired strain paths, which may be explained by the larger Young's moduli for the material, as determined from the triaxial compression tests. In the type 2 strain path tests, plots of the principal stress difference versus the principal strain difference show a characteristic pattern in the NV sand response. In both 2A and 2B strain paths, the specimens strain very little (1-2% strain difference) during loading to a stress difference of 5 to 7 MPa, followed by increased shear strain with minimal additional load.

The RDC, UDC, and UWS materials behave similar to each other in the type 2 strain path tests, but unlike the NV samples, the principal stress difference versus principal strain difference curves are nearly linear for almost the entire loading portion of the test. The stress-strain responses are similar among the three groups, although the UDC has a slightly stiffer response than the RDC material.

Greater variability, both among and between groups, is seen in the type 3 strain path tests, although the overall results are similar to the type 2 strain paths. The NV material is generally stiffer than the others, and the UDC has a greater stress response than the RDC.

APPENDIX A

SAMPLE HANDLING INSTRUCTIONS FOR UNDISTURBED

CARES-DRY AND DIRECT COURSE MATERIAL

SAMPLE HANDLING INSTRUCTIONS FOR UNDISTURBED CARES-DRY AND DIRECT COURSE MATERIAL[1]

1. Cut the box and foam rubber from around the sample to remove it from the box. Pulling the sample from the box may damage it.

2. Re-tape the box for storage of the remaining samples.

3. Freeze the samples before attempting to remove the aluminum foil and wood packers.

4. To remove the wood packers:

   a) Turn the sample upside down in order to remove the base packer first.

   b) Unfold the portion of the membrane which was folded over the rubber bands.

   c) Carefully cut the membrane where the packer and sample meet.

   d) Place the base on the sample and turn the sample upright.

   e) Repeat steps b and c and place the top cap on the sample.

NOTE: It is recommended that the membrane not be completely removed from the sample. Removal could result in material falling off.

---

1. Memo from James D. Cargile, March, 1983.

APPENDIX B

UNDISTURBED CORE SAMPLE

BORING AND DEPTH IDENTIFICATION

UNDISTURBED CARES-DRY (UDC) CORE SAMPLES

Box Number	Sample Number	Boring Number	Depth (meters) From	To
15	1	23	5.1	5.2
15	2	17	5.4	5.6
15	3	45	26.0	26.1
15	4	43	26.3	24.4
16	2	43	4.6	4.8
16	4	42	20.2	20.4
17	1	45	17.3	17.4
17	2	21	5.1	5.2
17	4	26	20.1	20.2
17	5	33	26.3	26.5
18	1	21	20.0	20.1
18	5	15	4.3	4.4
19	2	40	20.3	20.4
19	5	41	27.2	27.3
21	1	41	27.3	27.7
21	2	32	26.3	26.4
21	3	32	26.4	26.5
22	3	23	18.6	18.8
22	3	38	27.9	28.1

UNDISTURBED DIRECT COURSE (UWS) CORE SAMPLES

Box Number	Sample Number	Boring Number	Depth to Center of Specimen (meters)
1	1	21	9.3
1	3	21	2.0
2	1	21	5.4
2	3	25	5.7
2	4	29	6.5
3	3	25	12.3
4	1	21	15.5
4	2	21	9.7
4	4	26	2.2
5	2	31	14.1
5	3	21	1.4
5	4	34	12.4
5	5	32	24.6
6	1	34A	23.3
6	5	23	5.0
22	2	28	3.3
23	5	24	1.0
23	6	25	1.0

PLATES

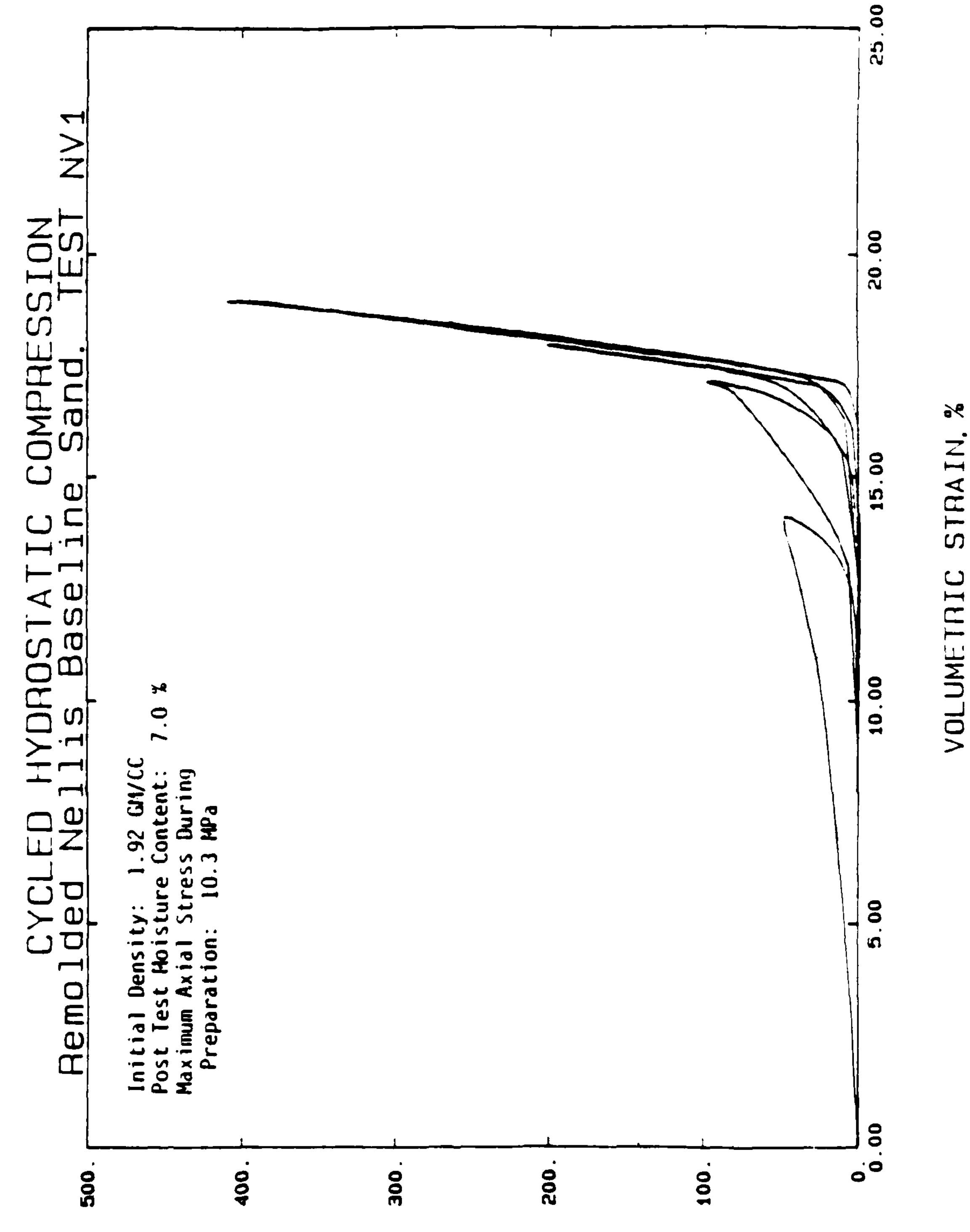
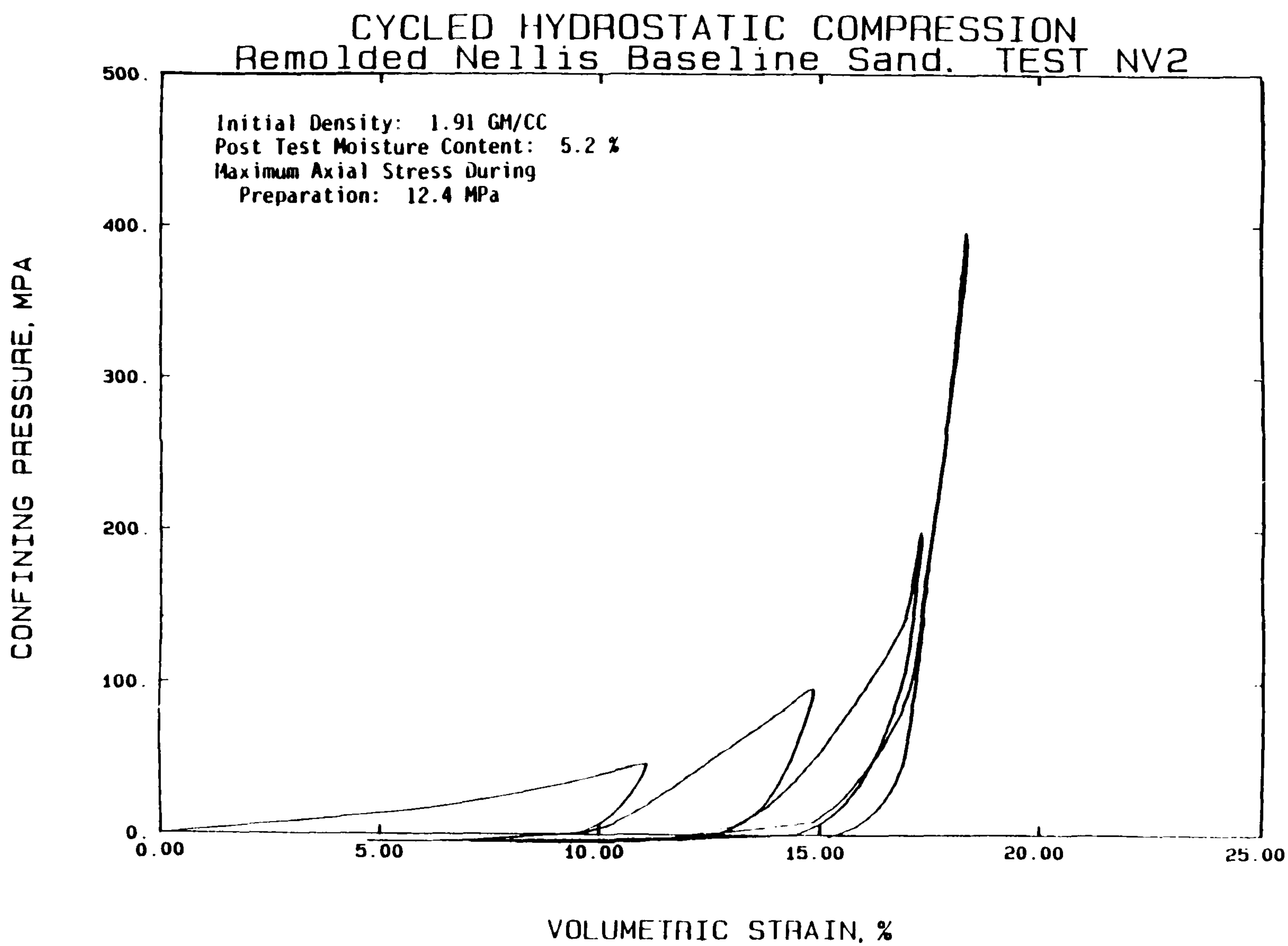

CYCLED HYDROSTATIC COMPRESSION
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.92 GM/CC
Post Test Moisture Content: 7.0 %
Maximum Axial Stress During
Preparation: 10.3 MPa
CONFINING PRESSURE, MPA
500.
400.
300.
200.
100.
0.
VOLUMETRIC STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00

Plate 1



CYCLED HYDROSTATIC COMPRESSION
Remolded Nellis Baseline Sand. TEST NV2
Initial Density: 1.91 GM/CC
Post Test Moisture Content: 5.2 %
Maximum Axial Stress During
Preparation: 12.4 MPa
CONFINING PRESSURE, MPA
500.
400.
300.
200.
100.
0.
0.00
5.00
10.00
15.00
20.00
25.00
VOLUMETRIC STRAIN, %

Plate 2

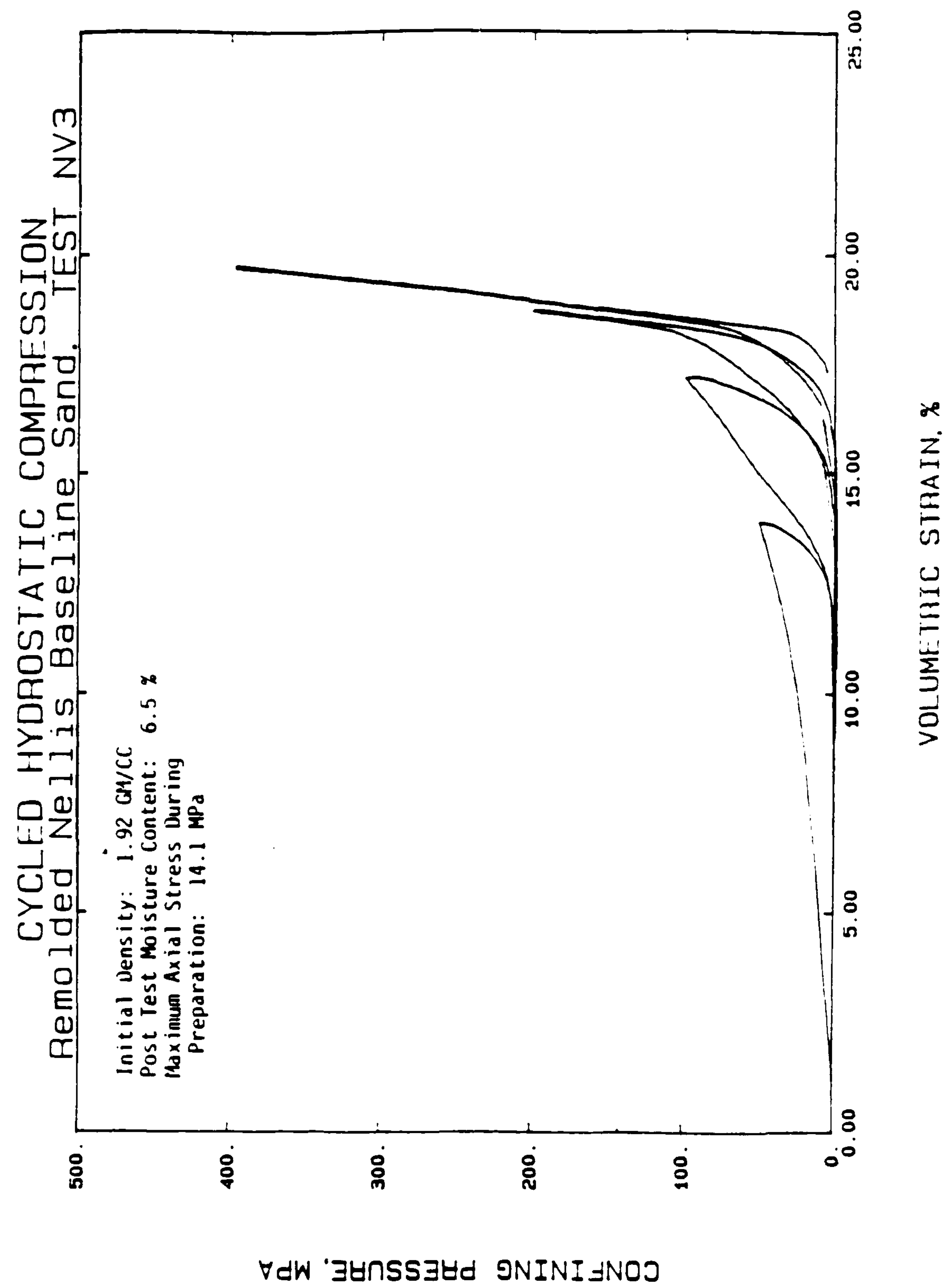

CYCLED HYDROSTATIC COMPRESSION
Remolded Nellis Baseline Sand, TEST NV3
Initial Density: 1.92 GM/CC
Post Test Moisture Content: 6.5 %
Maximum Axial Stress During
Preparation: 14.1 MPa
CONFINING PRESSURE, MPA
VOLUMETRIC STRAIN, %
0.
100.
200.
300.
400.
500.
0.00
5.00
10.00
15.00
20.00
25.00

Plate 3

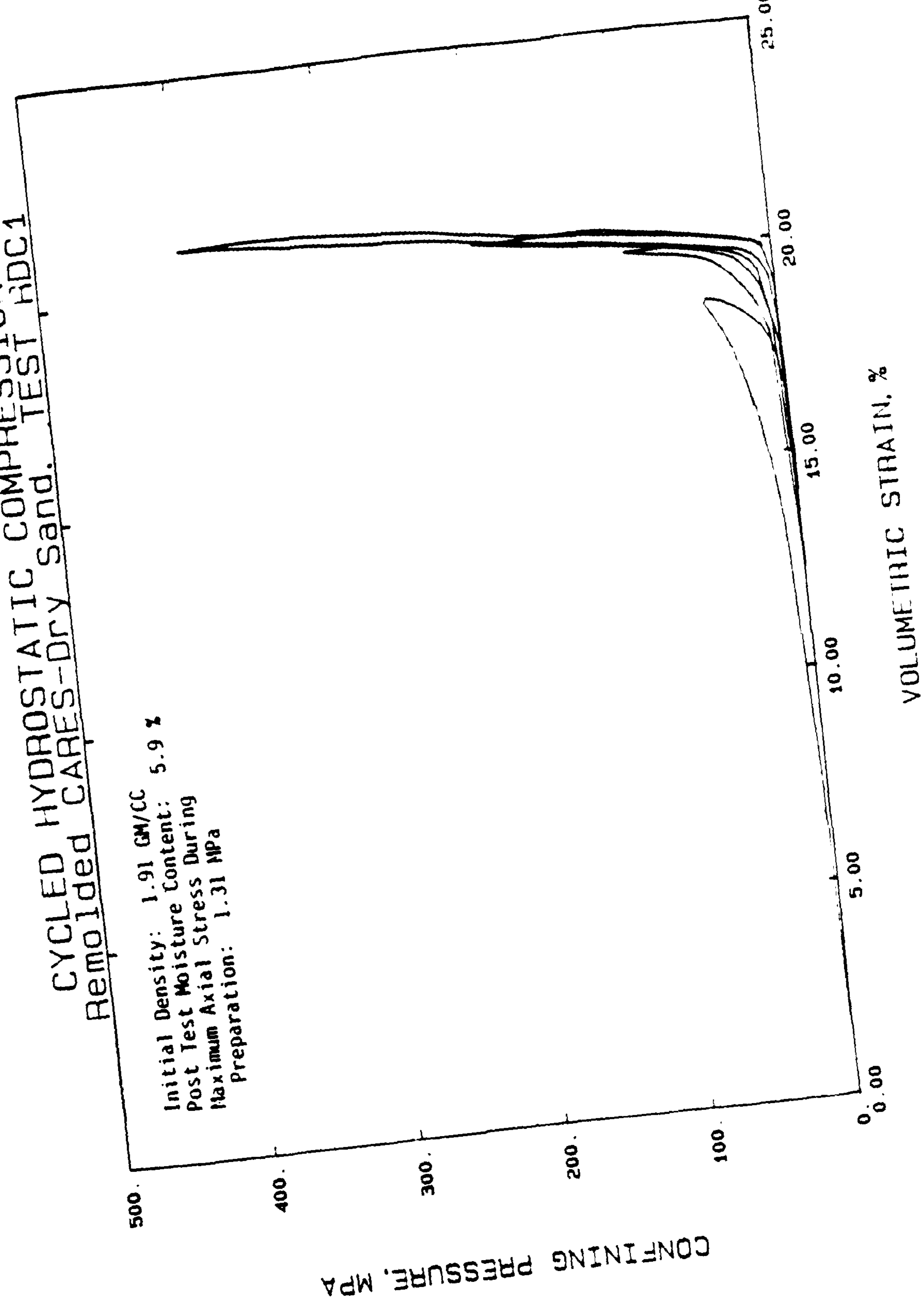

CYCLED HYDROSTATIC COMPRESSION
Remolded CARES-Dry Sand. TEST HDC1
Initial Density: 1.91 GM/CC
Post Test Moisture Content: 5.9 %
Maximum Axial Stress During
Preparation: 1.31 MPa
CONFINING PRESSURE, MPA
VOLUMETRIC STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00
0.
100.
200.
300.
400.
500.

Plate 4

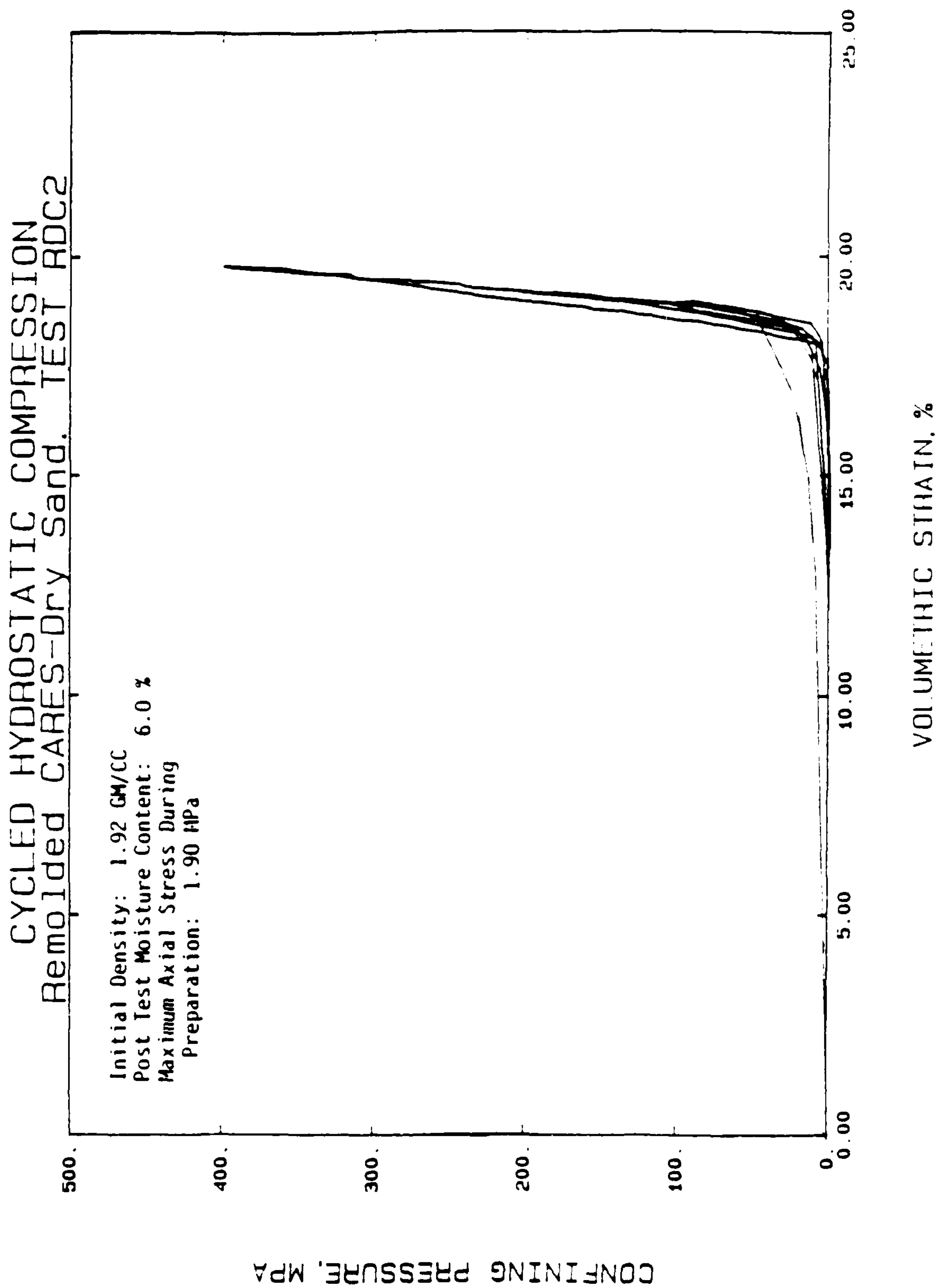

CYCLED HYDROSTATIC COMPRESSION
Remolded CARES-Dry Sand. TEST RDC2
Initial Density: 1.92 GM/CC
Post Test Moisture Content: 6.0 %
Maximum Axial Stress During
Preparation: 1.90 MPa
VOLUMETRIC STRAIN, %
CONFINING PRESSURE, MPA
0.00
5.00
10.00
15.00
20.00
25.00
0.
100.
200.
300.
400.
500.

Plate 5

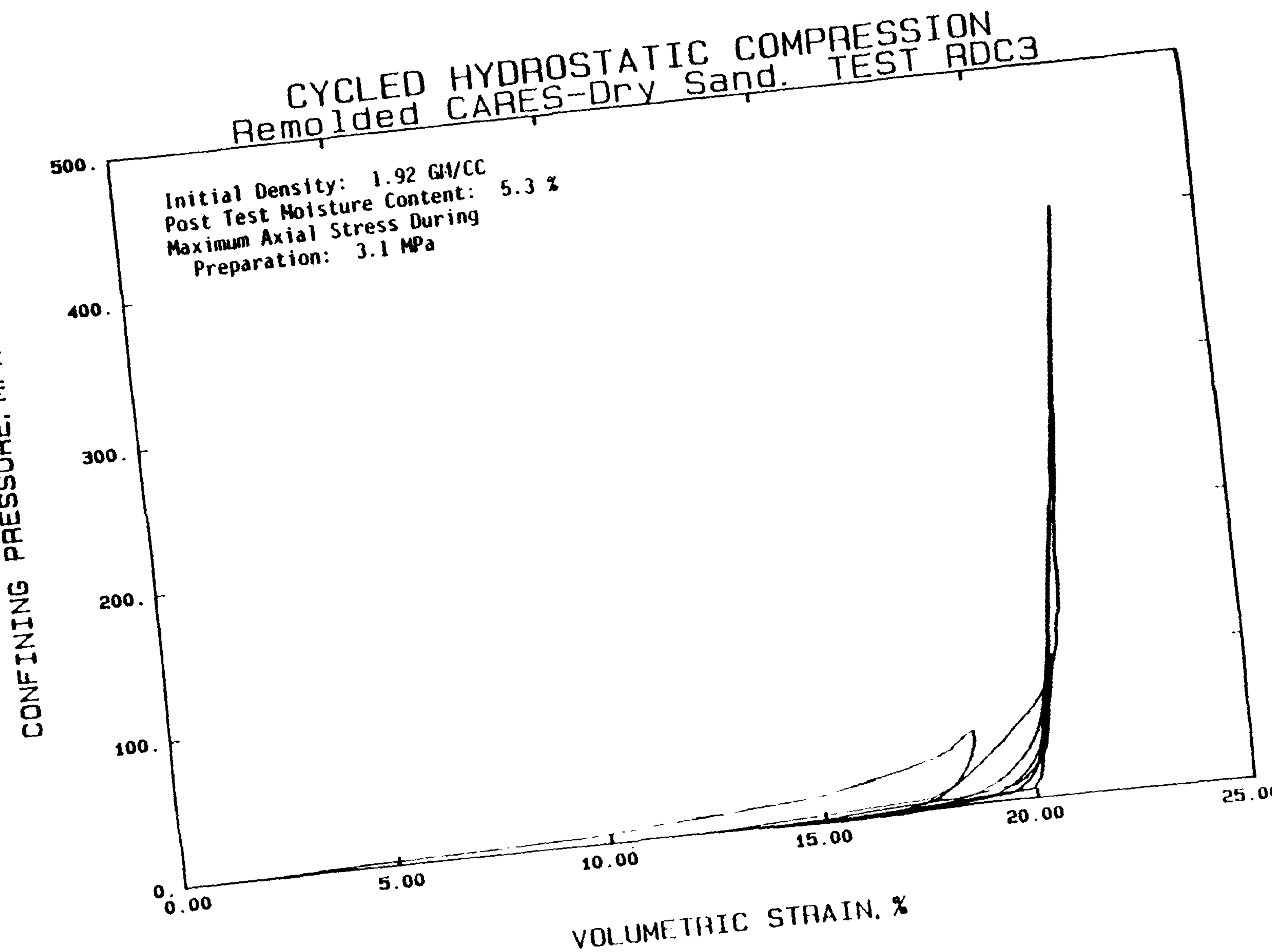

CYCLED HYDROSTATIC COMPRESSION
Remolded CARES-Dry Sand. TEST RDC3
Initial Density: 1.92 GM/CC
Post Test Moisture Content: 5.3 %
Maximum Axial Stress During
Preparation: 3.1 MPa
CONFINING PRESSURE, MPA
0.
100.
200.
300.
400.
500.
0.00
5.00
10.00
15.00
20.00
25.00
VOLUMETRIC STRAIN, %

Plate 6

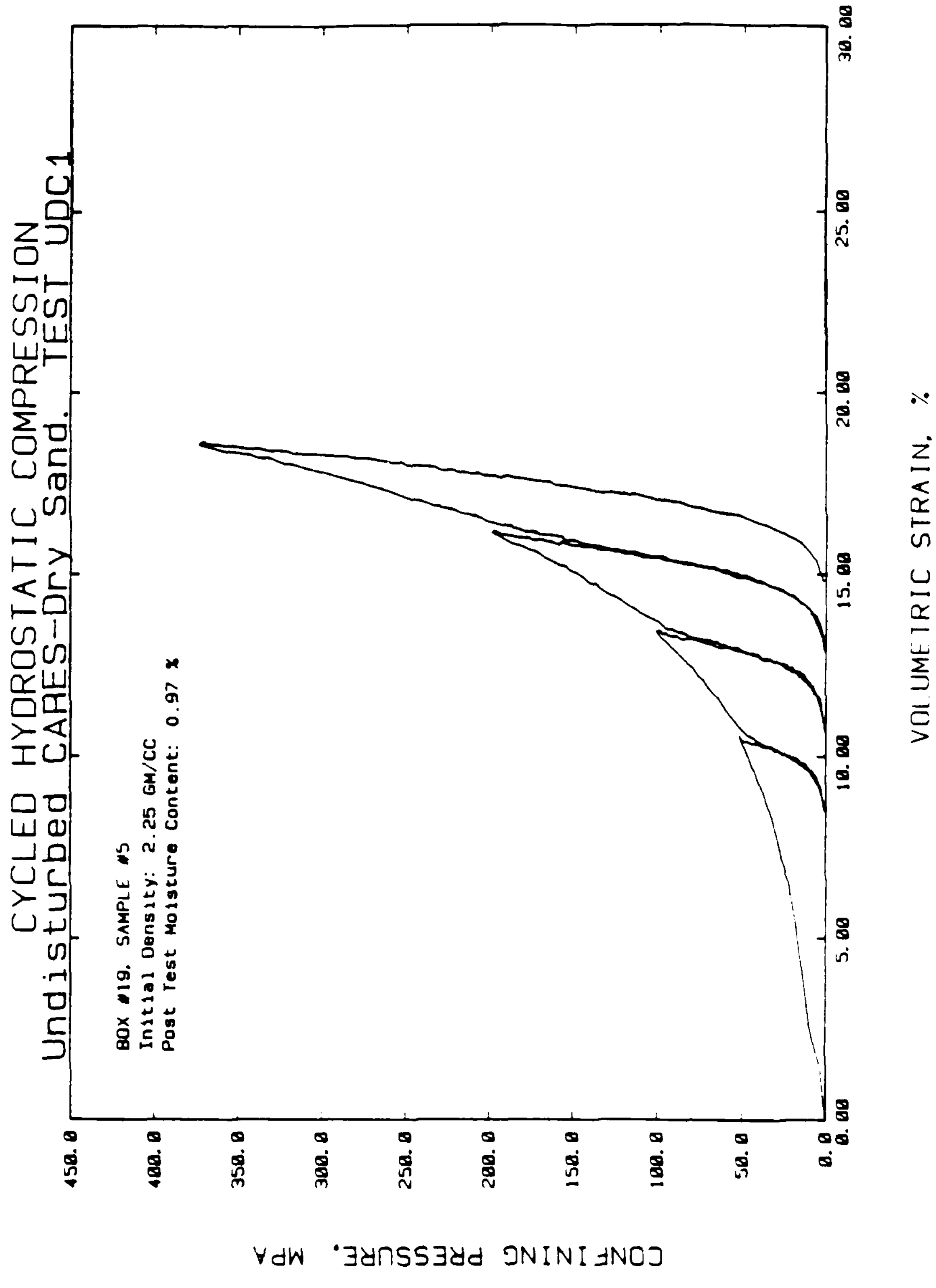

CYCLED HYDROSTATIC COMPRESSION
Undisturbed CARES-Dry Sand. TEST UDC1
BOX #19, SAMPLE #5
Initial Density: 2.25 GM/CC
Post Test Moisture Content: 0.97 %
CONFINING PRESSURE, MPA
VOLUMETRIC STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 7

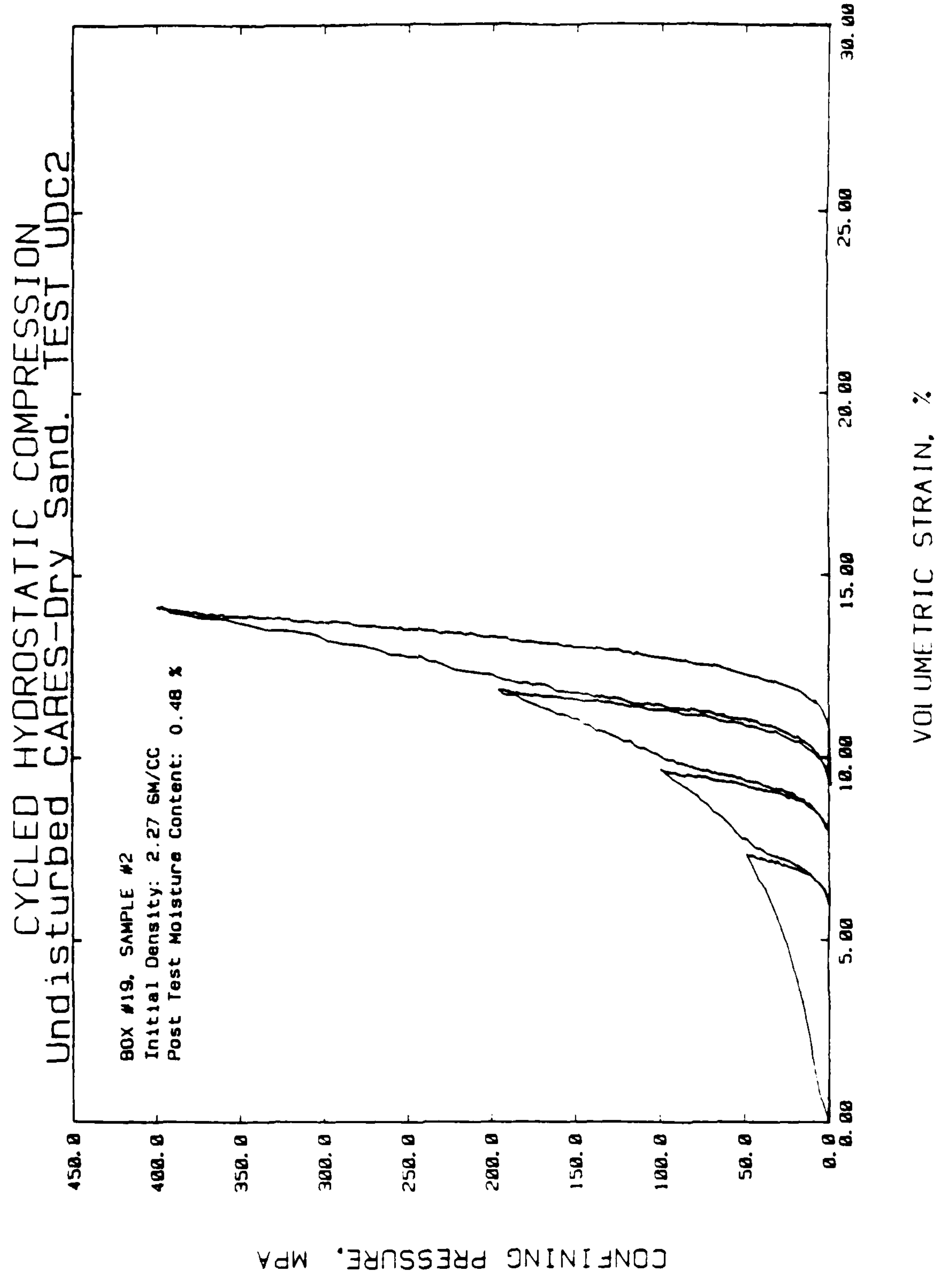

CYCLED HYDROSTATIC COMPRESSION
Undisturbed CARES-Dry Sand. TEST UDC2
BOX #19. SAMPLE #2
Initial Density: 2.27 GM/CC
Post Test Moisture Content: 0.48 %
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
CONFINING PRESSURE, MPA
0.00
5.00
10.00
15.00
20.00
25.00
30.00
VOLUMETRIC STRAIN, %

Plate 8

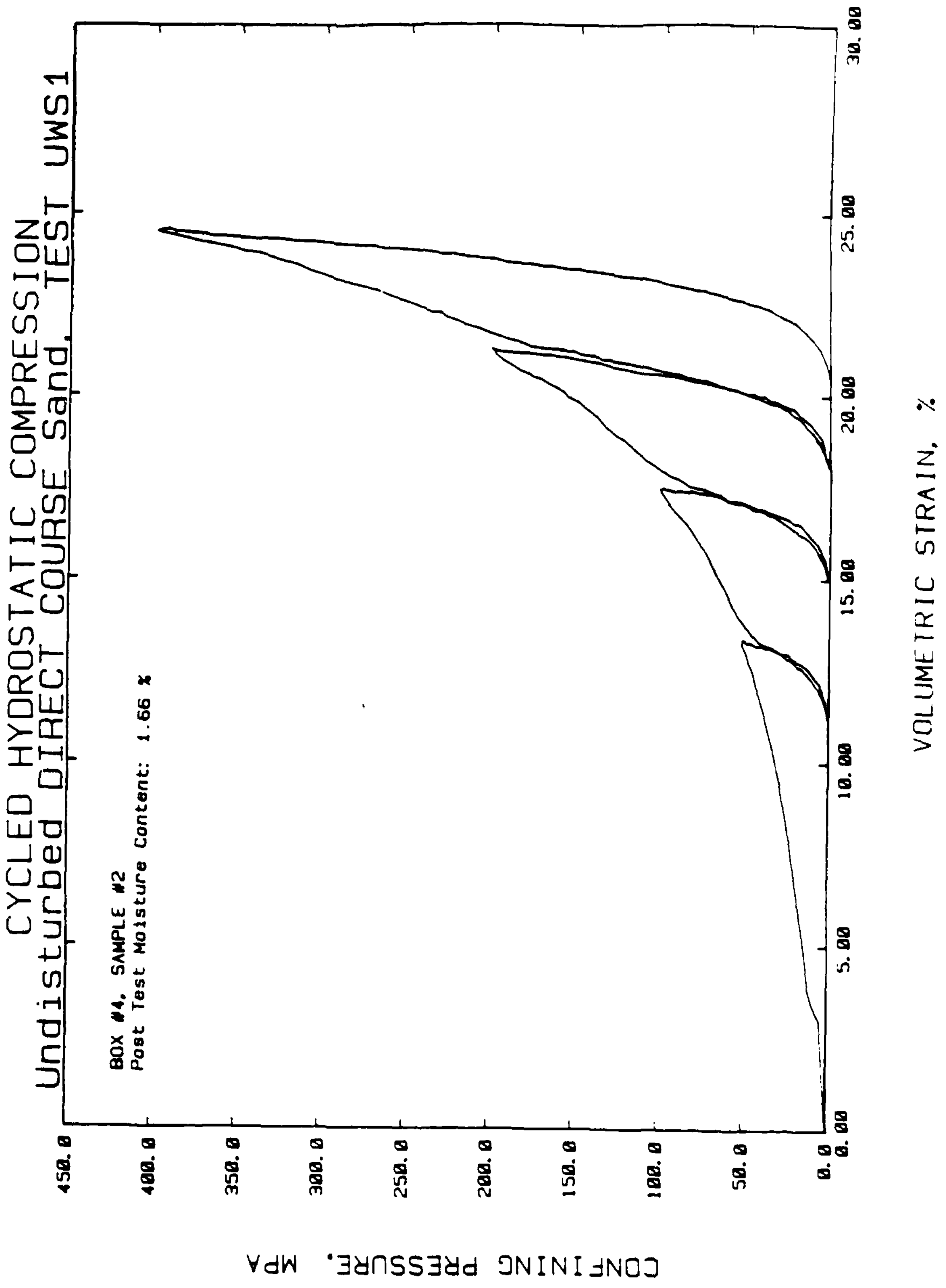

CYCLED HYDROSTATIC COMPRESSION
Undisturbed DIRECT COURSE Sand, TEST UWS1
BOX #4, SAMPLE #2
Post Test Moisture Content: 1.66 %
CONFINING PRESSURE, MPA
VOLUMETRIC STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 9

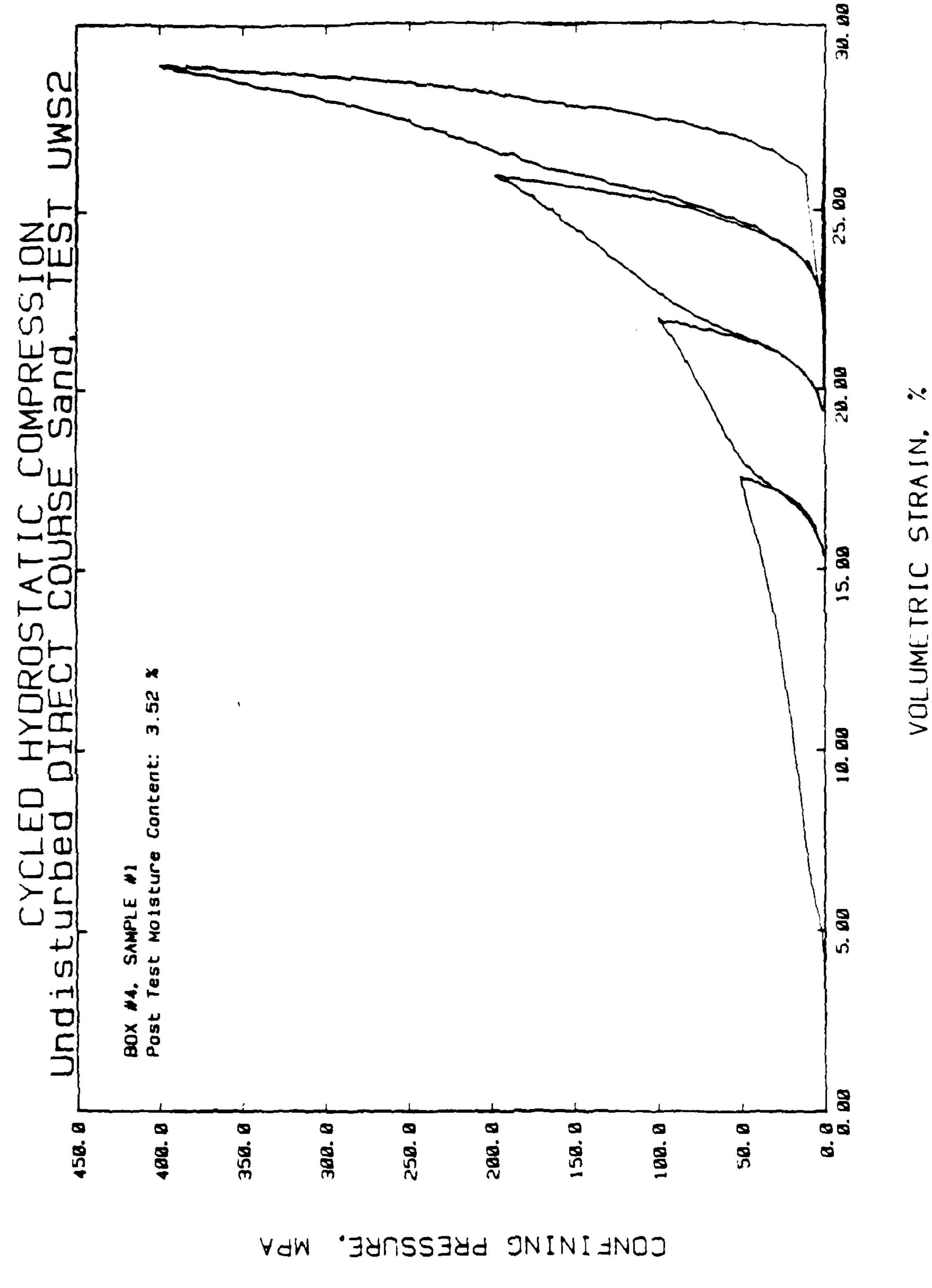

CYCLED HYDROSTATIC COMPRESSION
Undisturbed DIRECT COURSE Sand, TEST UWS2
BOX #4, SAMPLE #1
Post Test Moisture Content: 3.52 %
CONFINING PRESSURE, MPA
VOLUMETRIC STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 10

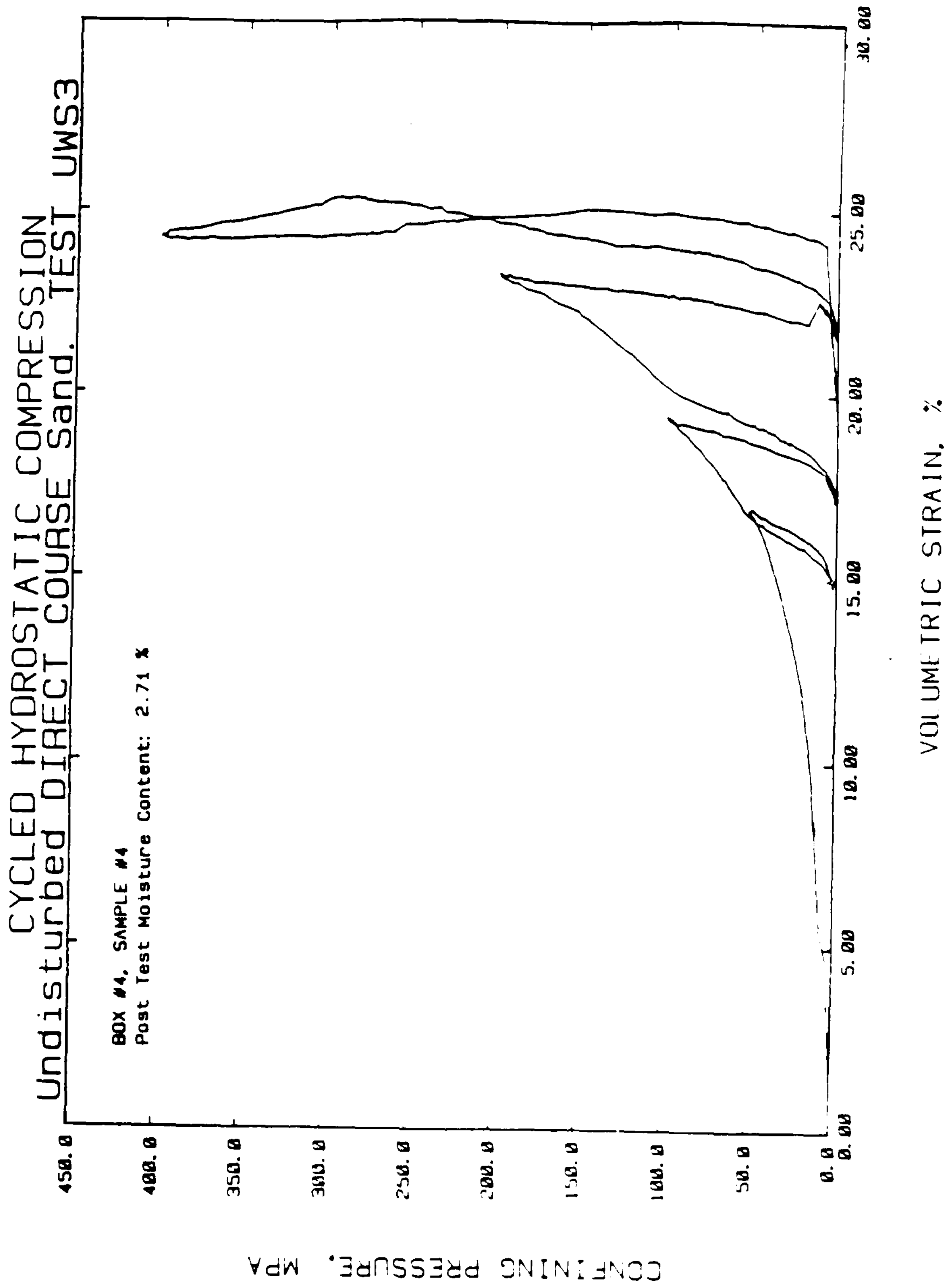
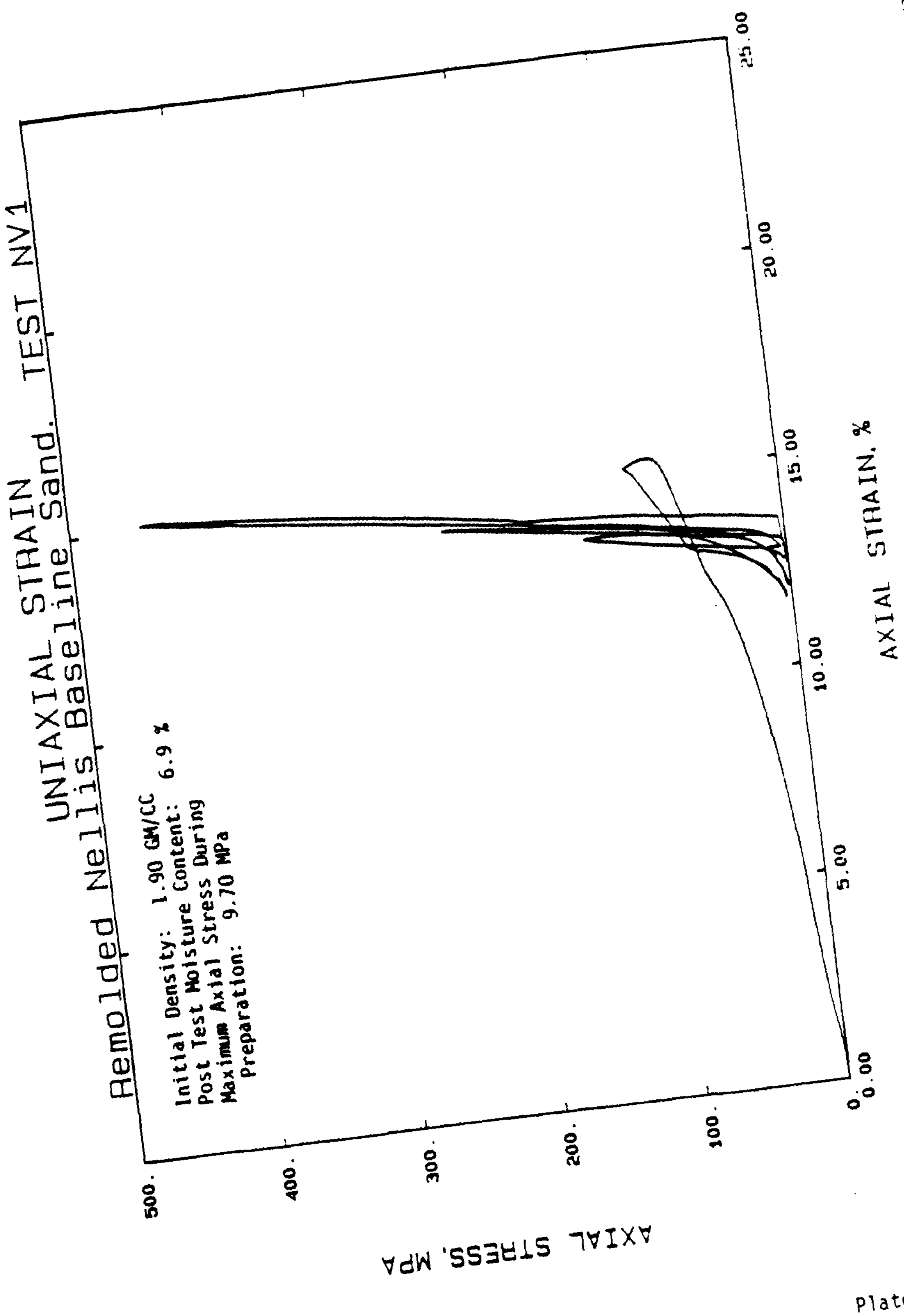
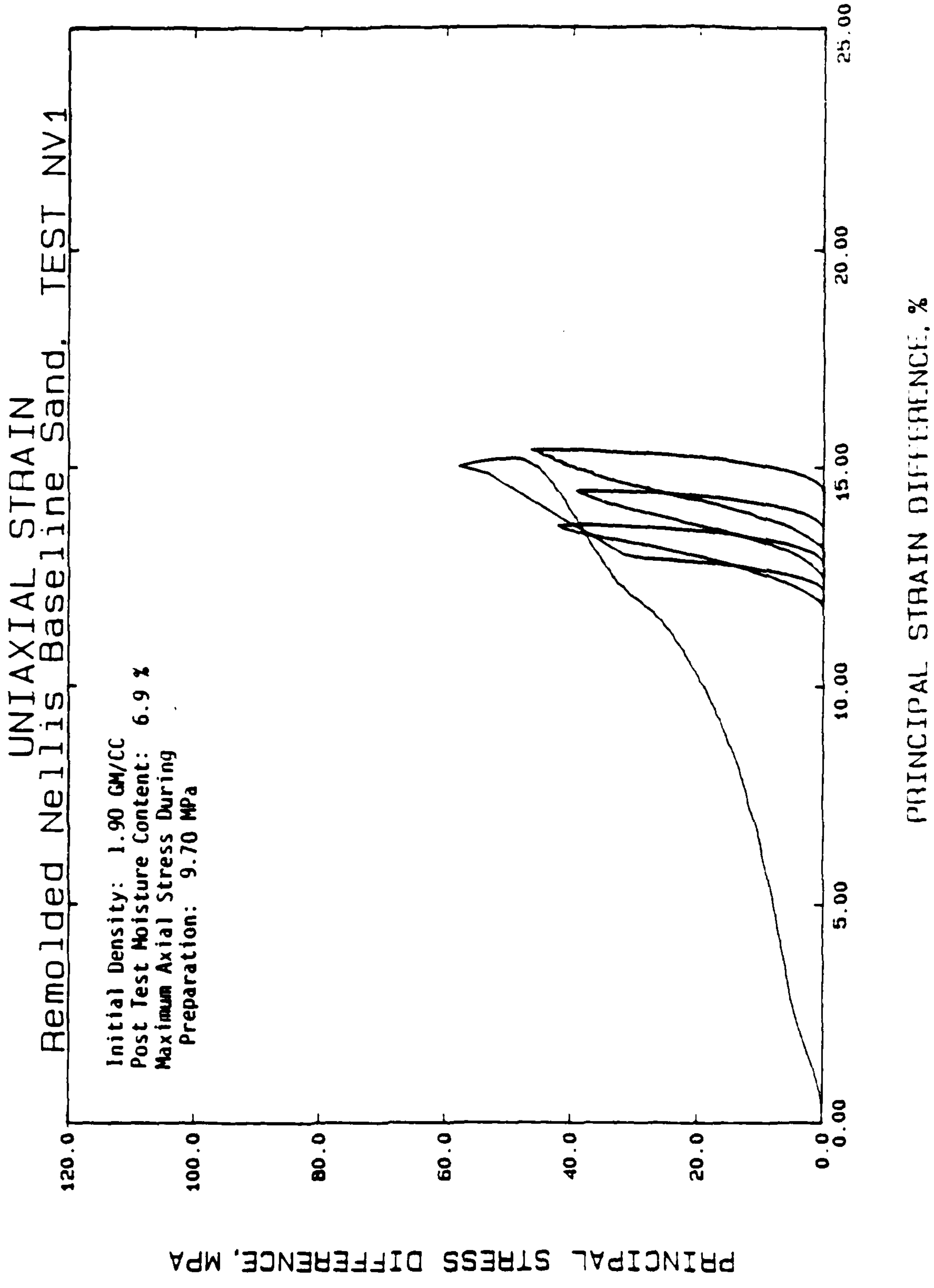

CYCLED HYDROSTATIC COMPRESSION
Undisturbed DIRECT COURSE Sand. TEST UWS3
BOX #4, SAMPLE #4
Post Test Moisture Content: 2.71 %
CONFINING PRESSURE, MPA
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
VOLUMETRIC STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 11



UNIAXIAL STRAIN
Remolded Nellis Baseline Sand. TEST NV1
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 6.9 %
Maximum Axial Stress During
Preparation: 9.70 MPa
AXIAL STRESS, MPA
0.
100.
200.
300.
400.
500.
AXIAL STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00

Plate 12



UNIAXIAL STRAIN
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 6.9 %
Maximum Axial Stress During
Preparation: 9.70 MPa
0.00
5.00
10.00
15.00
20.00
25.00
PRINCIPAL STRAIN DIFFERENCE, %
0.0
20.0
40.0
60.0
80.0
100.0
120.0
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 13

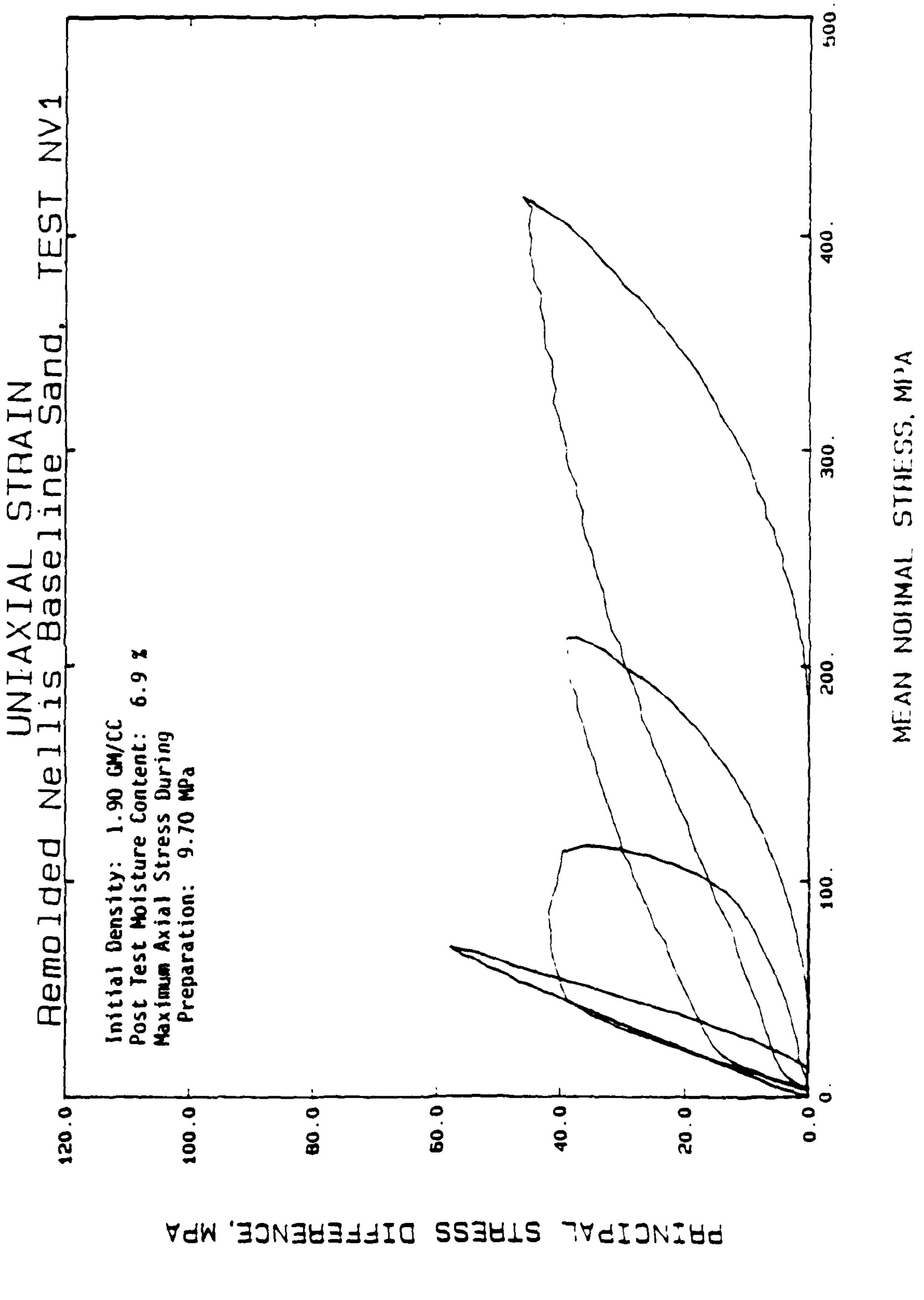
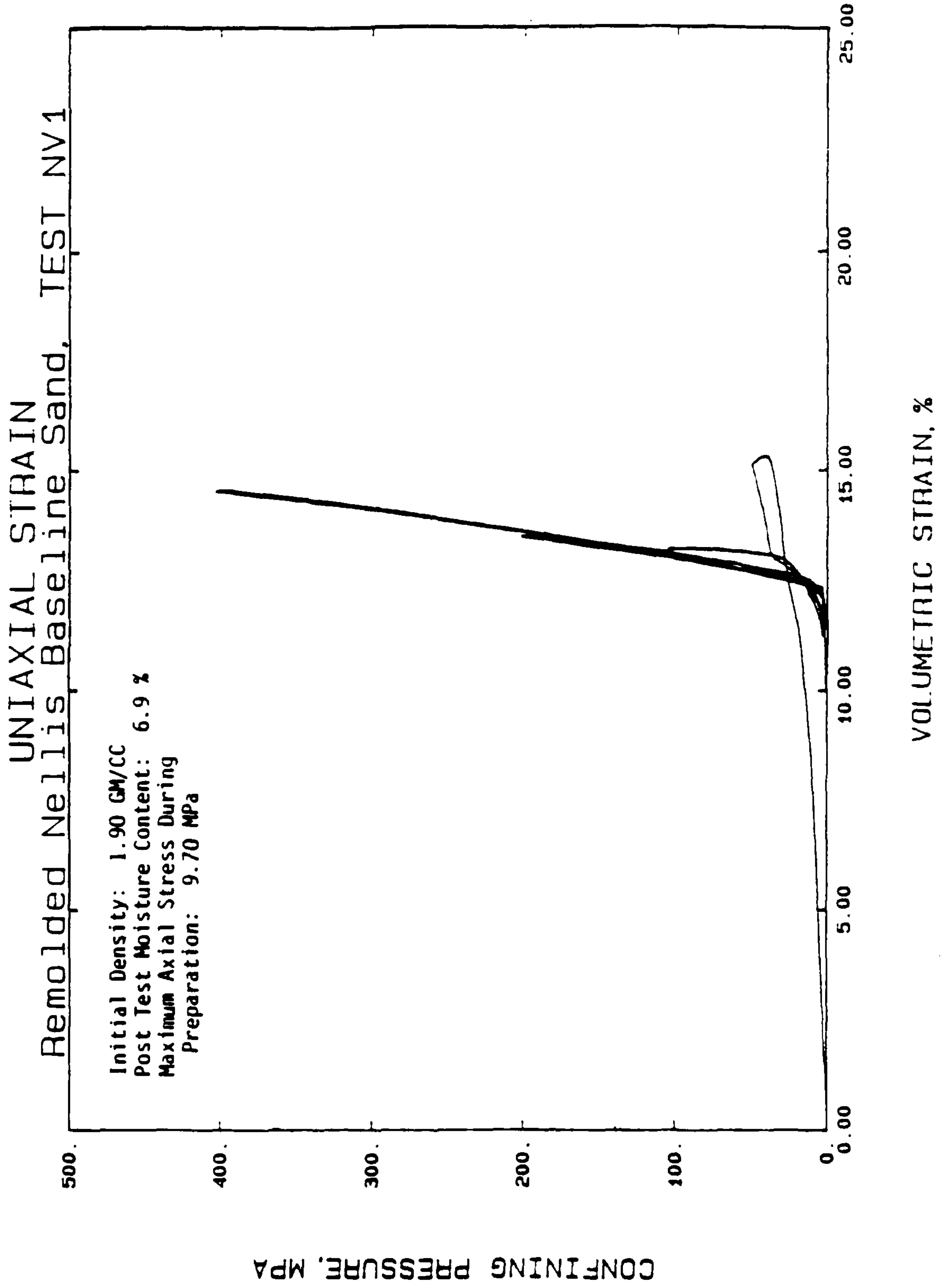
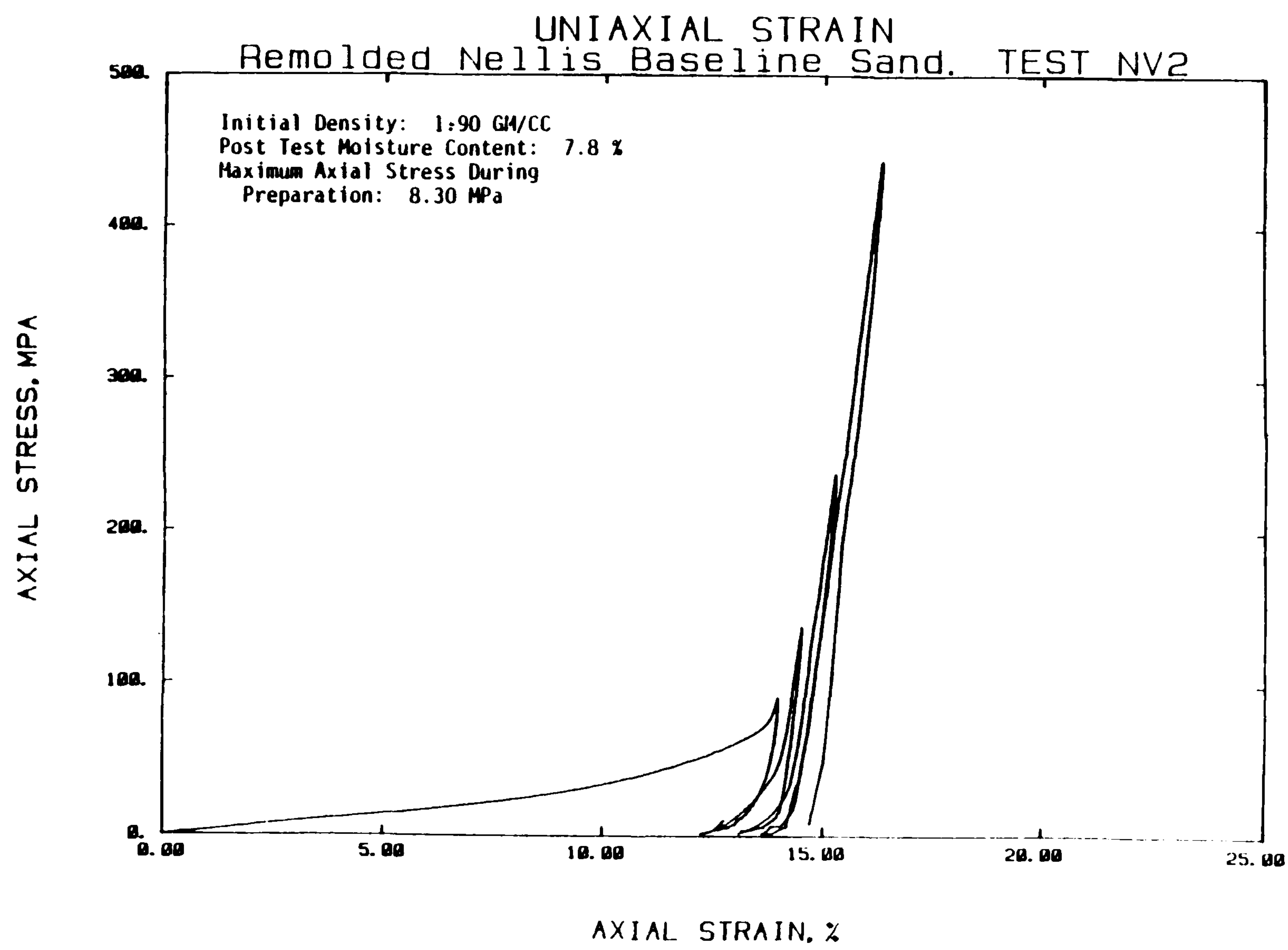
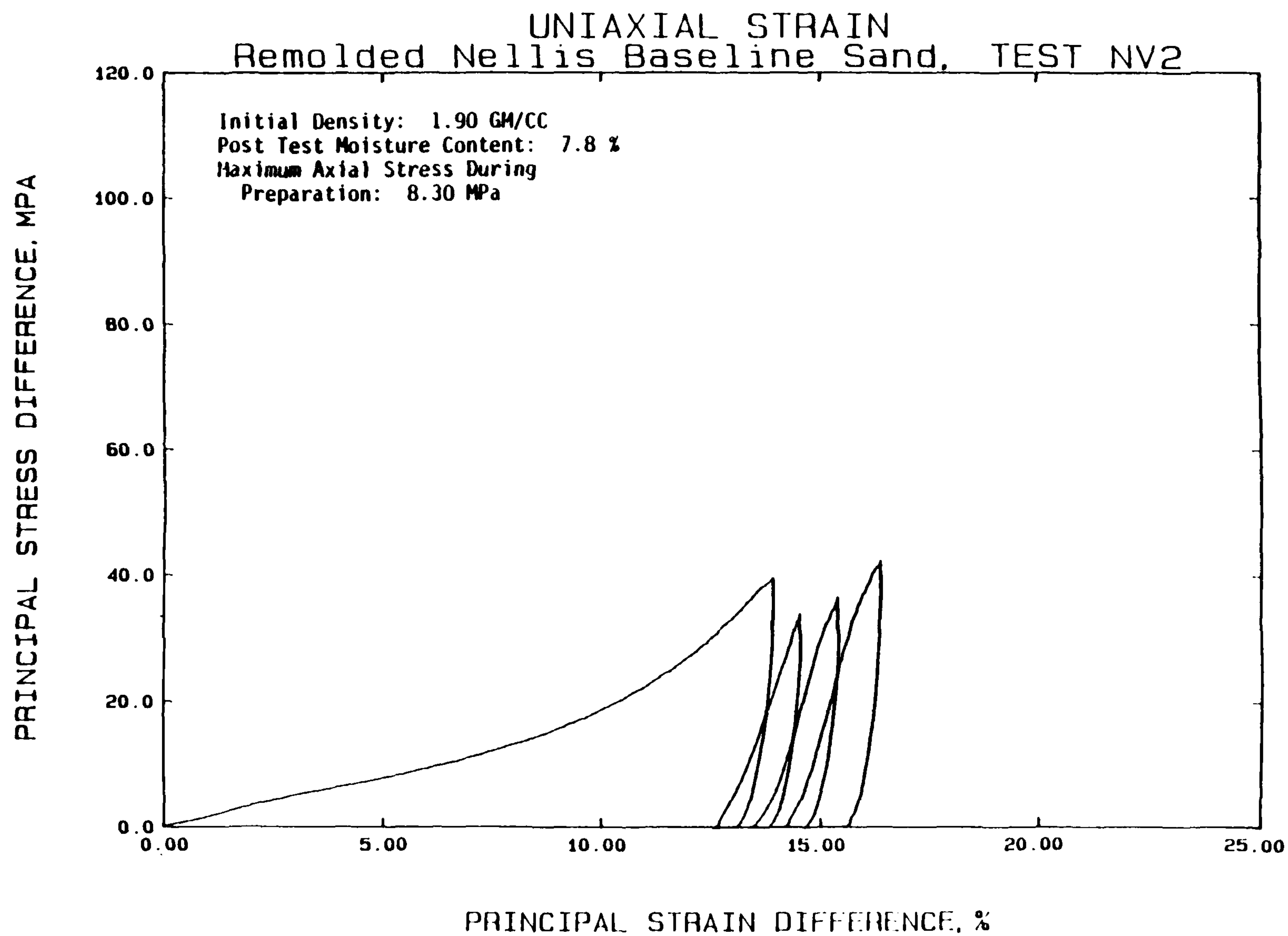

UNIAXIAL STRAIN
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 6.9 %
Maximum Axial Stress During
Preparation: 9.70 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
0.0
20.0
40.0
60.0
80.0
100.0
120.0
MEAN NORMAL STRESS, MPA
0
100
200
300
400
500

Plate 14


UNIAXIAL STRAIN
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 6.9 %
Maximum Axial Stress During
Preparation: 9.70 MPa
500.
400.
300.
200.
100.
0.
0.00
5.00
10.00
15.00
20.00
25.00
VOLUMETRIC STRAIN, %
CONFINING PRESSURE, MPA


UNIAXIAL STRAIN
Remolded Nellis Baseline Sand. TEST NV2
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 7.8 %
Maximum Axial Stress During
Preparation: 8.30 MPa
500.
400.
300.
200.
100.
0.
0.00
5.00
10.00
15.00
20.00
25.00
AXIAL STRESS, MPA
AXIAL STRAIN, %



UNIAXIAL STRAIN
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 7.8 %
Maximum Axial Stress During
Preparation: 8.30 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.00
5.00
10.00
15.00
20.00
25.00
PRINCIPAL STRAIN DIFFERENCE, %

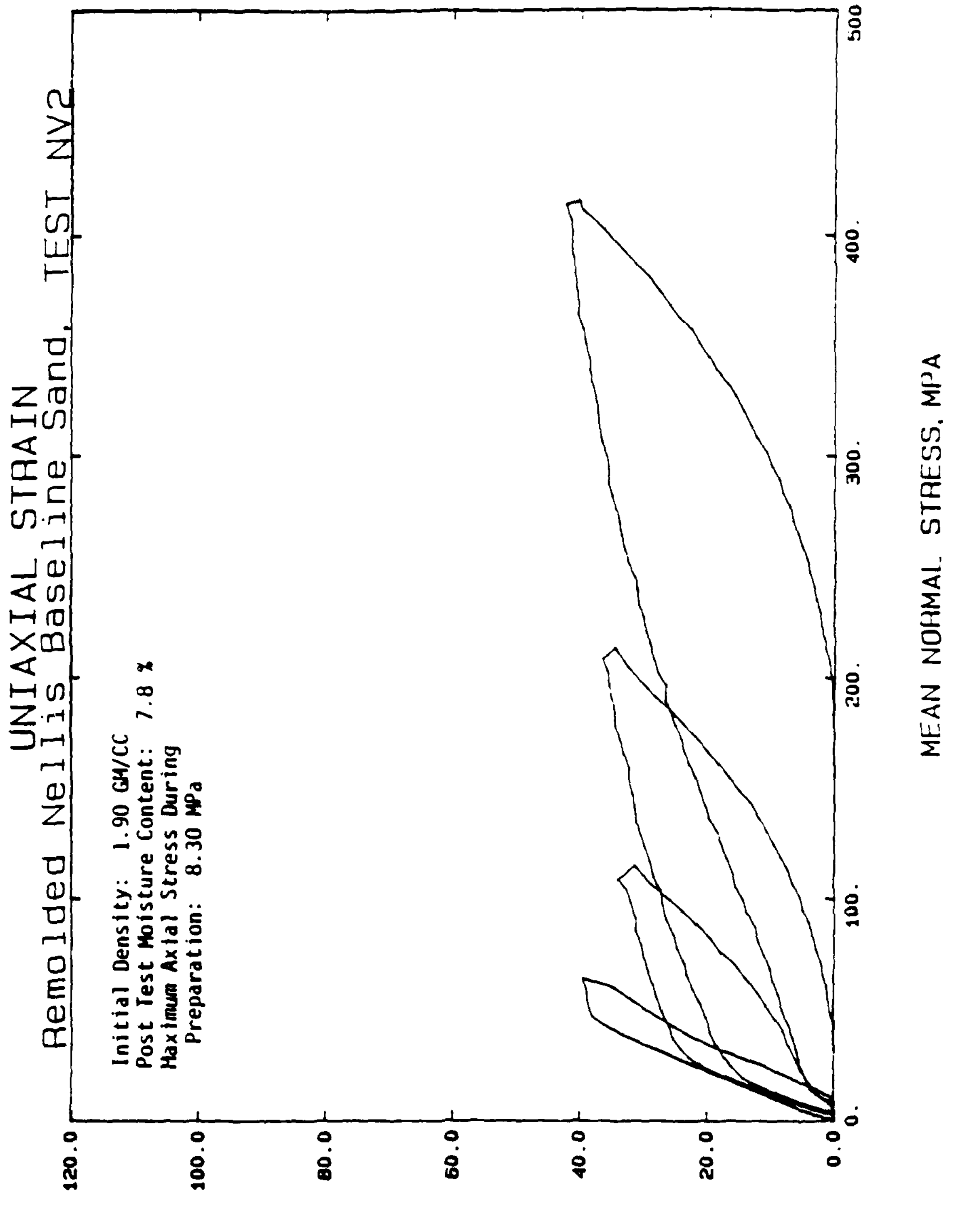

UNIAXIAL STRAIN
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 7.8 %
Maximum Axial Stress During
Preparation: 8.30 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
0.0
20.0
40.0
60.0
80.0
100.0
120.0
0.
100.
200.
300.
400.
500.

Plate 18

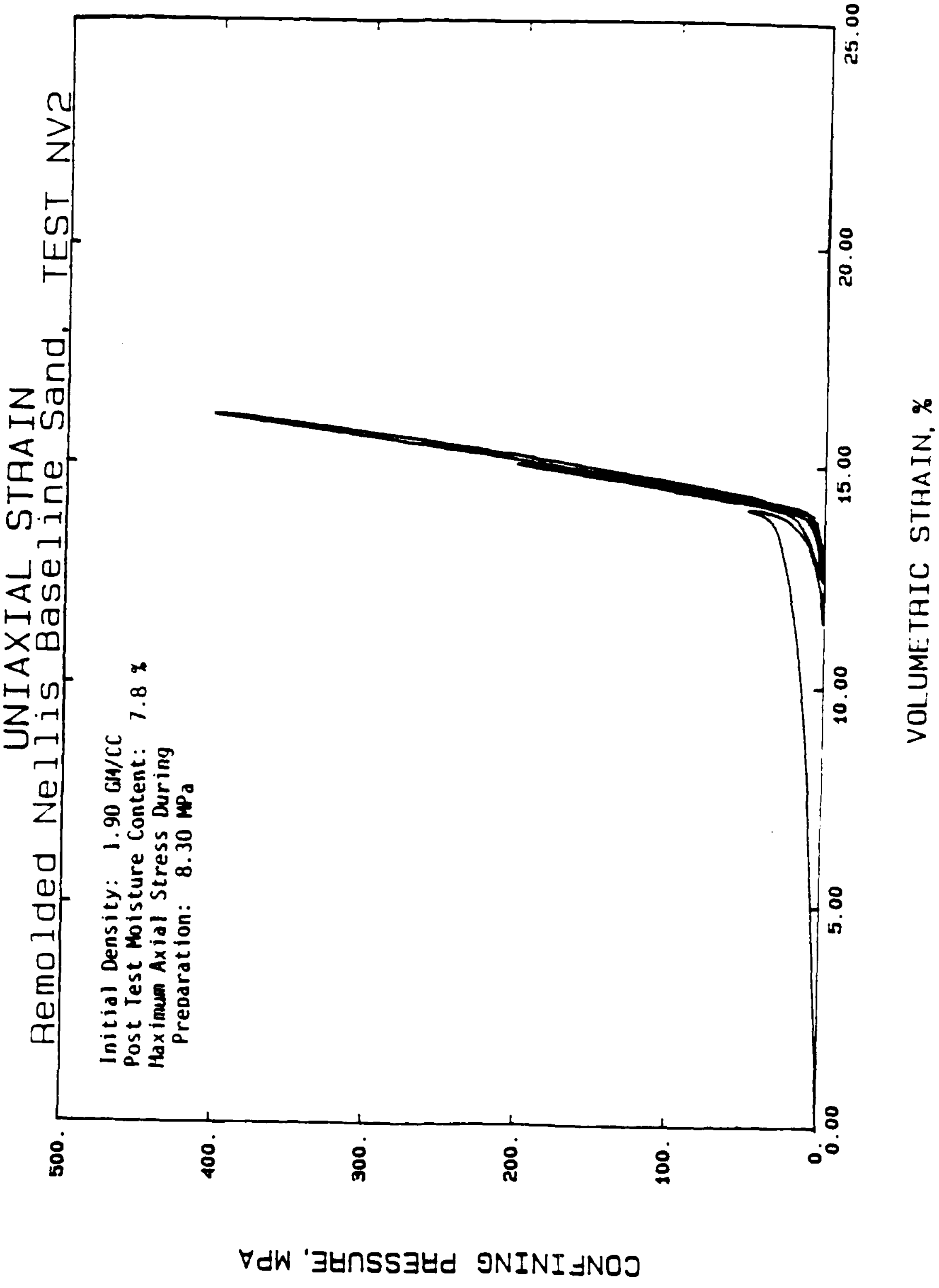
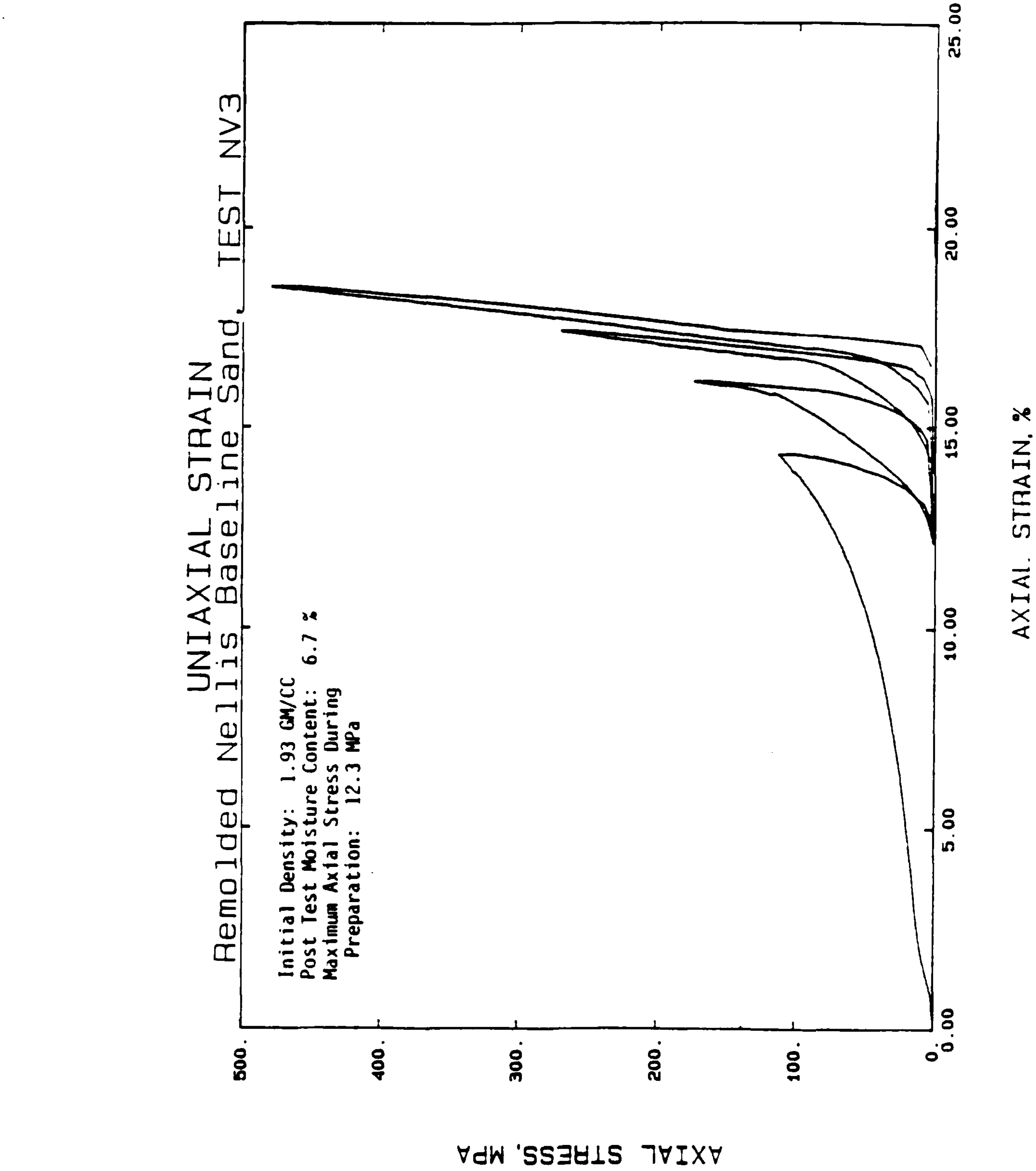
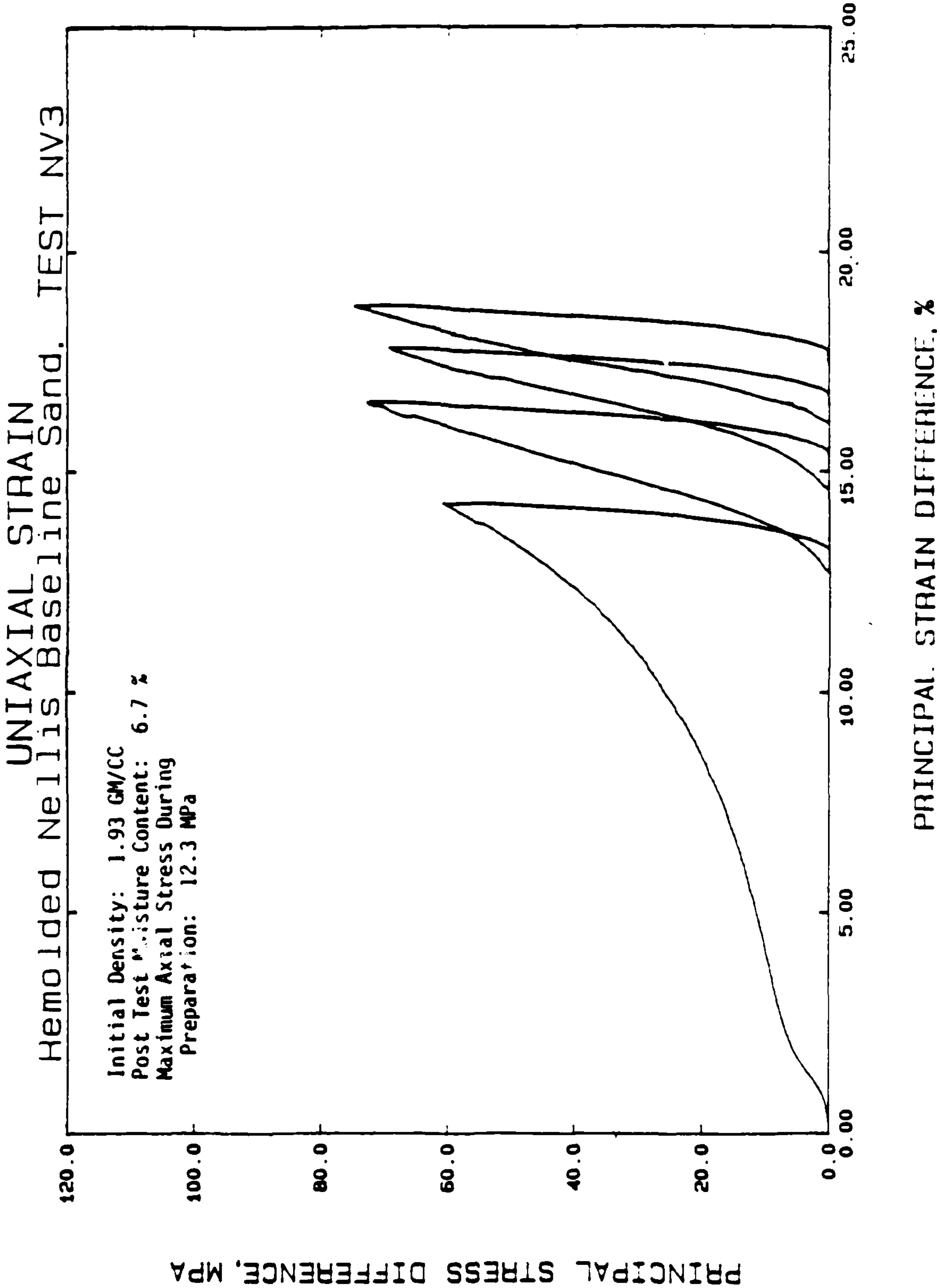

UNIAXIAL STRAIN
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 7.8 %
Maximum Axial Stress During
Preparation: 8.30 MPa
500.
400.
300.
200.
100.
0.
0.00
5.00
10.00
15.00
20.00
25.00
VOLUMETRIC STRAIN, %
CONFINING PRESSURE, MPA

Plate 19


UNIAXIAL STRAIN
Remolded Nellis Baseline Sand, TEST NV3
Initial Density: 1.93 GM/CC
Post Test Moisture Content: 6.7 %
Maximum Axial Stress During
Preparation: 12.3 MPa
0.00
5.00
10.00
15.00
20.00
25.00
AXIAL STRAIN, %
0.
100.
200.
300.
400.
500.
AXIAL STRESS, MPA


UNIAXIAL STRAIN
Remolded Nellis Baseline Sand. TEST NV3
Initial Density: 1.93 GM/CC
Post Test Moisture Content: 6.7 %
Maximum Axial Stress During
Preparation: 12.3 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
0.0
20.0
40.0
60.0
80.0
100.0
120.0
PRINCIPAL STRAIN DIFFERENCE, %
0.00
5.00
10.00
15.00
20.00
25.00

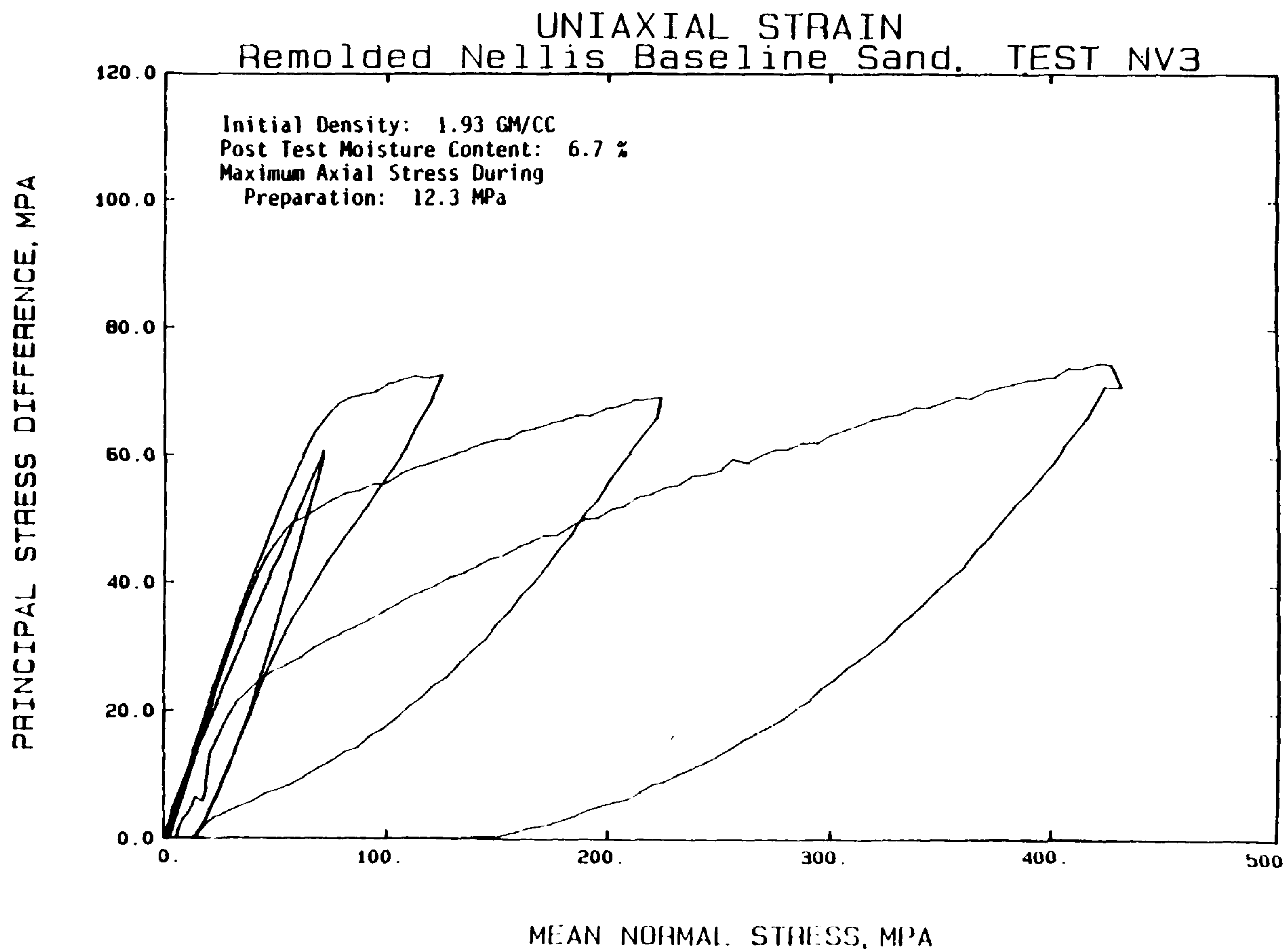
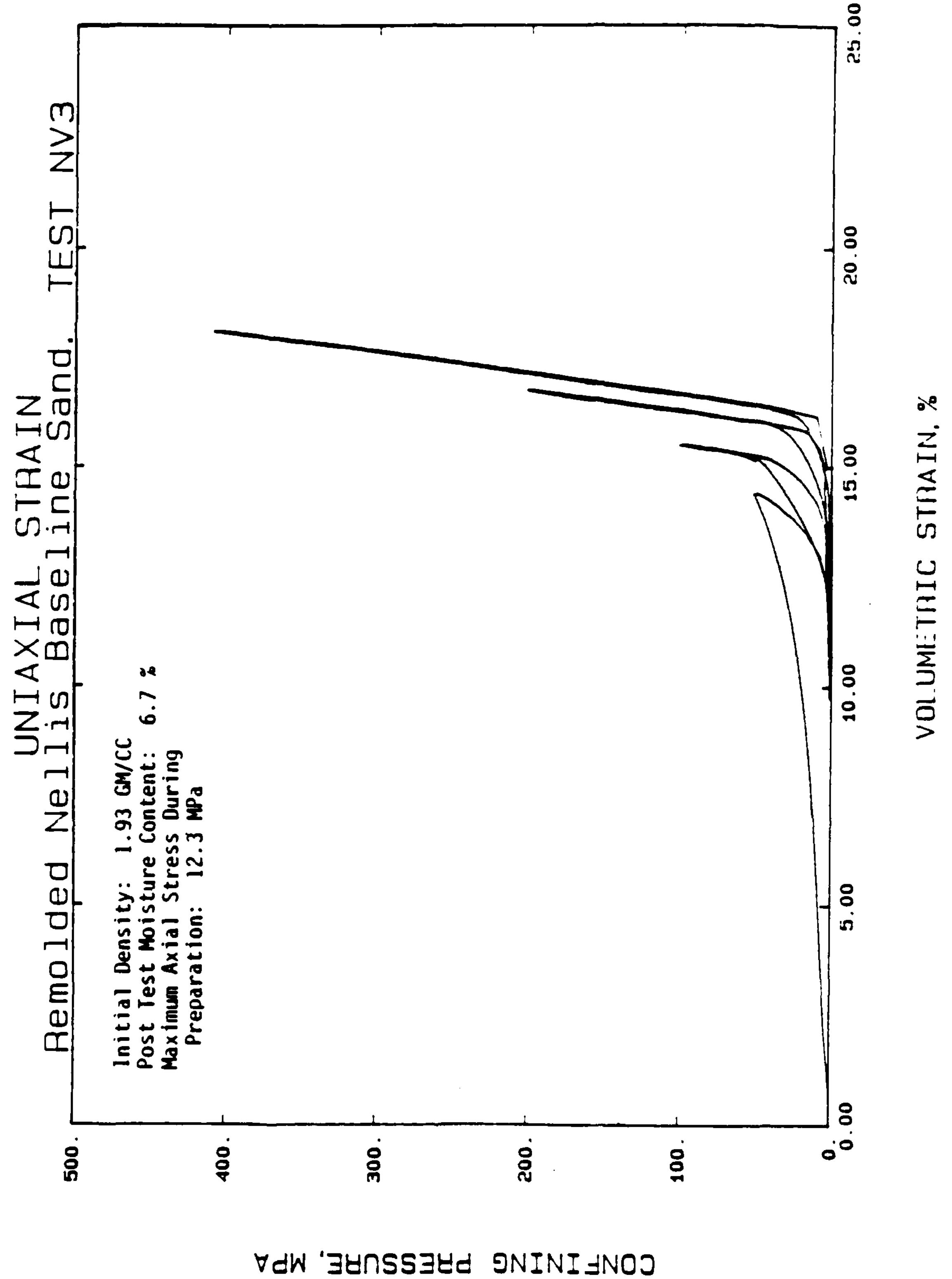
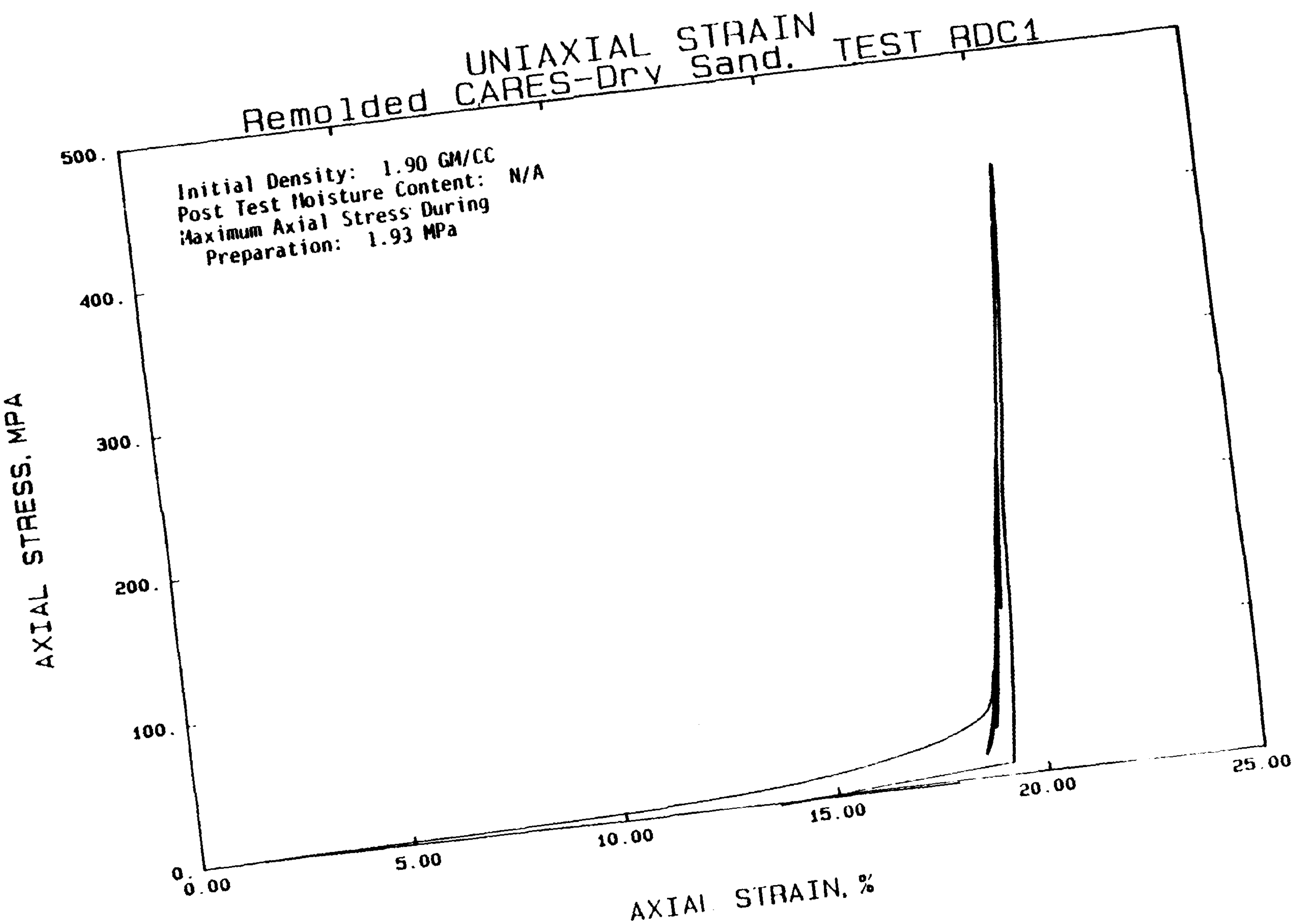

UNIAXIAL STRAIN
Remolded Nellis Baseline Sand, TEST NV3
Initial Density: 1.93 GM/CC
Post Test Moisture Content: 6.7 %
Maximum Axial Stress During
Preparation: 12.3 MPa
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.
100.
200.
300.
400.
500.
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA

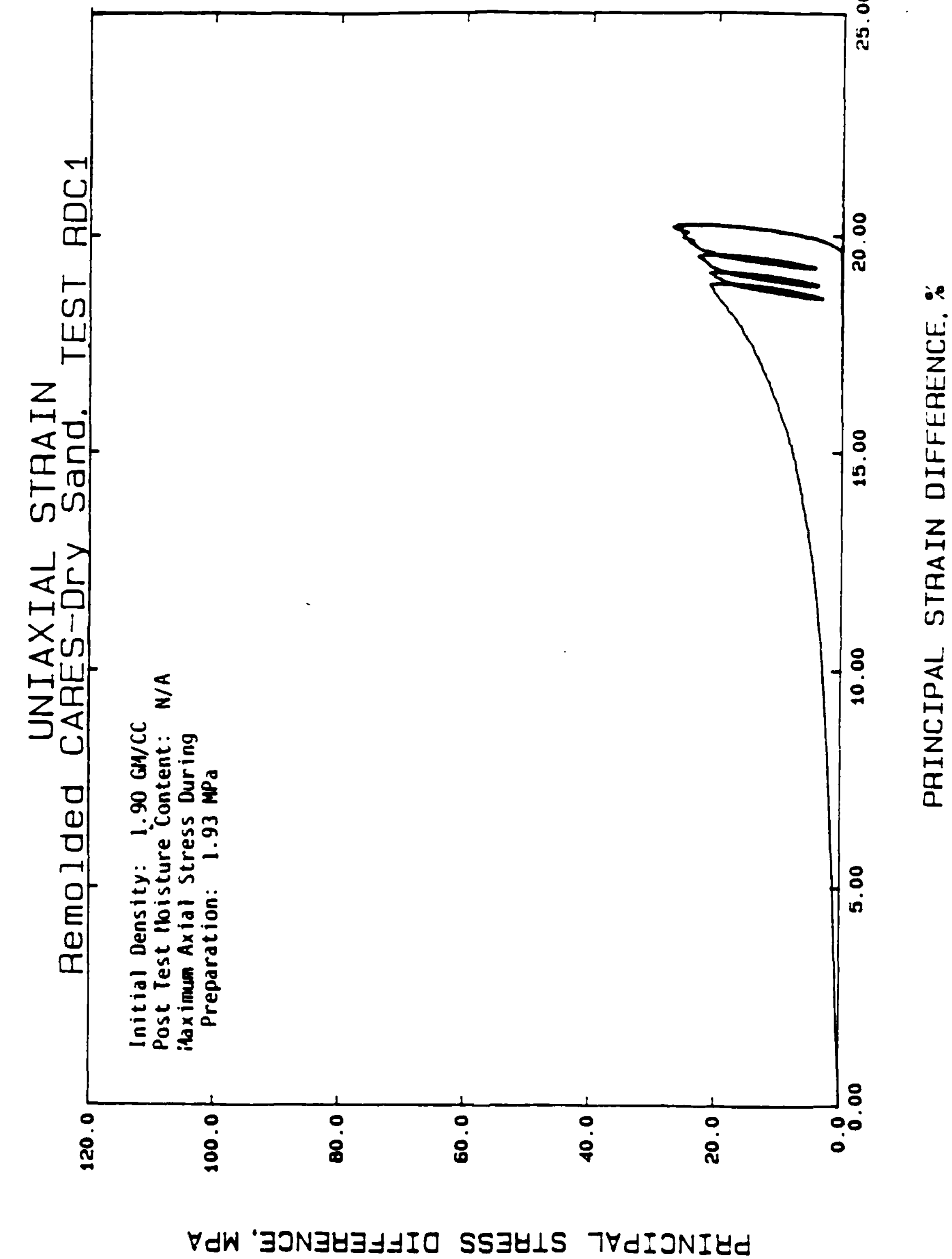
Plate 22



UNIAXIAL STRAIN
Remolded Nellis Baseline Sand. TEST NV3
Initial Density: 1.93 GM/CC
Post Test Moisture Content: 6.7 %
Maximum Axial Stress During
Preparation: 12.3 MPa
CONFINING PRESSURE, MPA
0.
100.
200.
300.
400.
500.
VOLUMETRIC STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00

Plate 23


UNIAXIAL STRAIN
Remolded CARES-Dry Sand. TEST RDC1
Initial Density: 1.90 GM/CC
Post Test Moisture Content: N/A
Maximum Axial Stress During
Preparation: 1.93 MPa
AXIAL STRESS, MPA
500.
400.
300.
200.
100.
0.
0.00
5.00
10.00
15.00
20.00
25.00
AXIAL STRAIN, %



UNIAXIAL STRAIN
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.90 GM/CC
Post Test Moisture Content: N/A
Maximum Axial Stress During
Preparation: 1.93 MPa
0.00
5.00
10.00
15.00
20.00
25.00
PRINCIPAL STRAIN DIFFERENCE, %
0.0
20.0
40.0
60.0
80.0
100.0
120.0
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 25

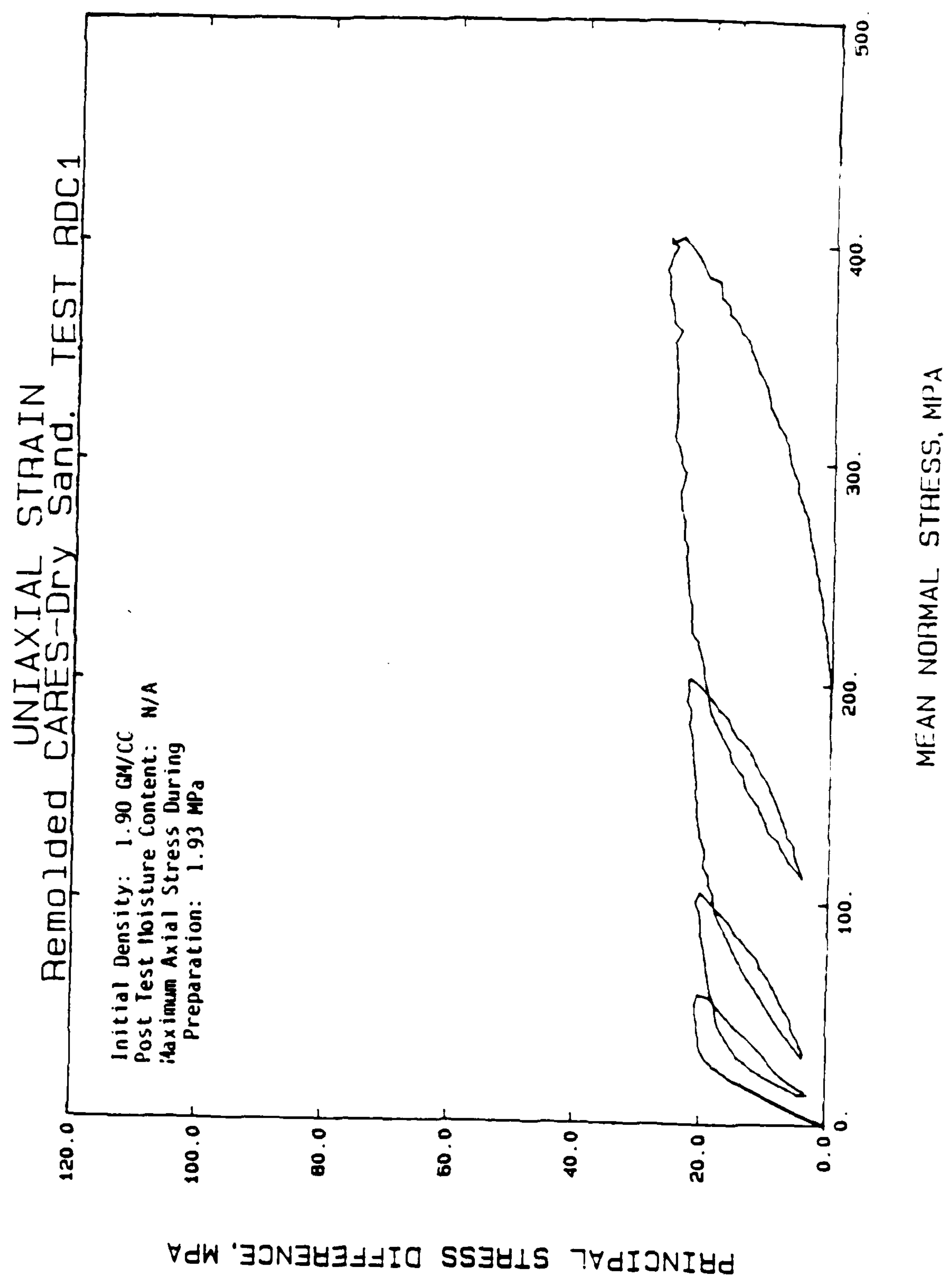

UNIAXIAL STRAIN
Remolded CARES-Dry Sand. TEST RDC1
Initial Density: 1.90 GM/CC
Post Test Moisture Content: N/A
Maximum Axial Stress During
Preparation: 1.93 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
0.0
20.0
40.0
60.0
80.0
100.0
120.0
MEAN NORMAL STRESS, MPA
0.
100.
200.
300.
400.
500.

Plate 26

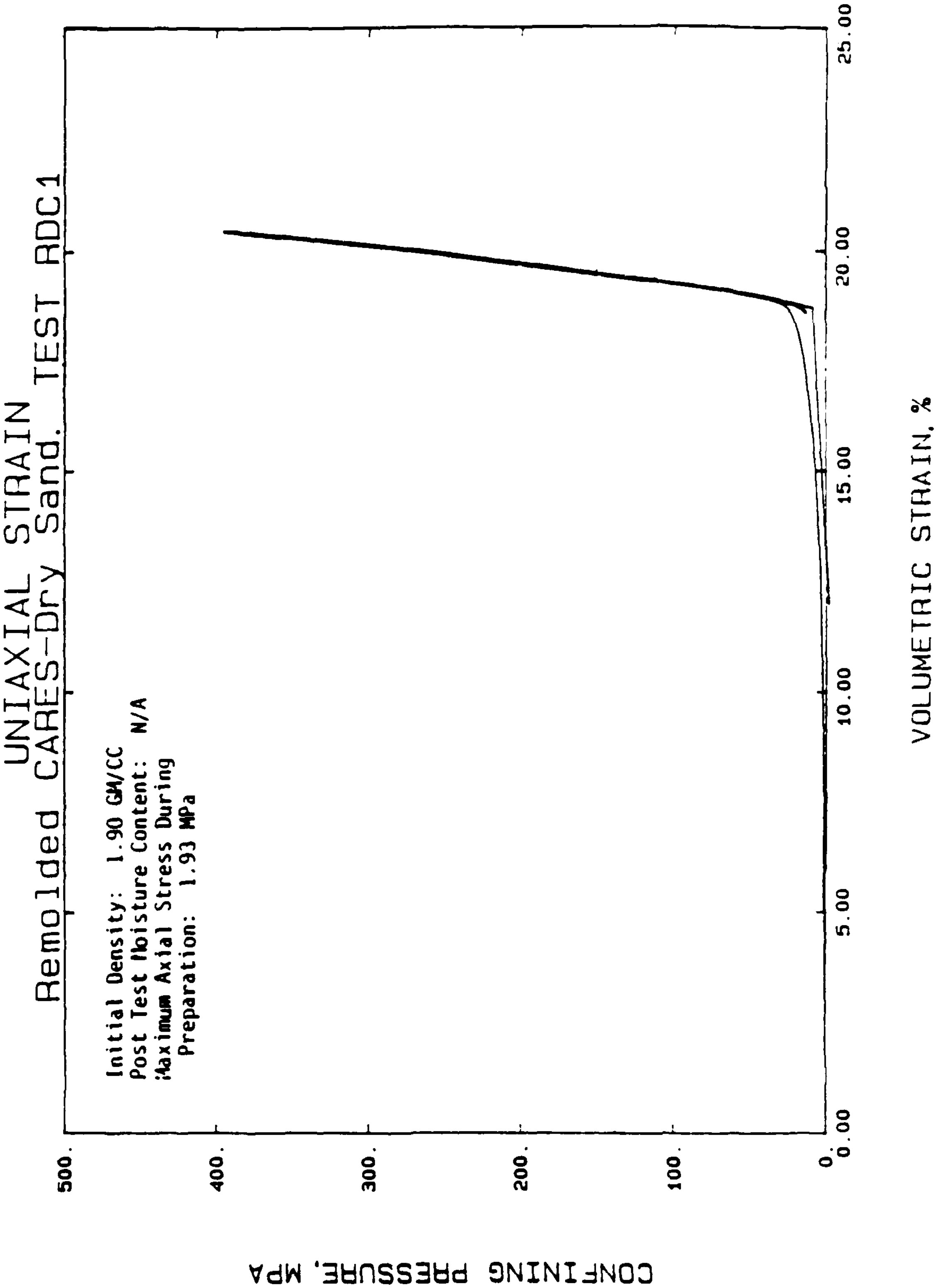

UNIAXIAL STRAIN
Remolded CARES-Dry Sand. TEST RDC1
Initial Density: 1.90 GM/CC
Post Test Moisture Content: N/A
Maximum Axial Stress During
Preparation: 1.93 MPa
0.00
5.00
10.00
15.00
20.00
25.00
VOLUMETRIC STRAIN, %
0.
100.
200.
300.
400.
500.
CONFINING PRESSURE, MPA

Plate 27

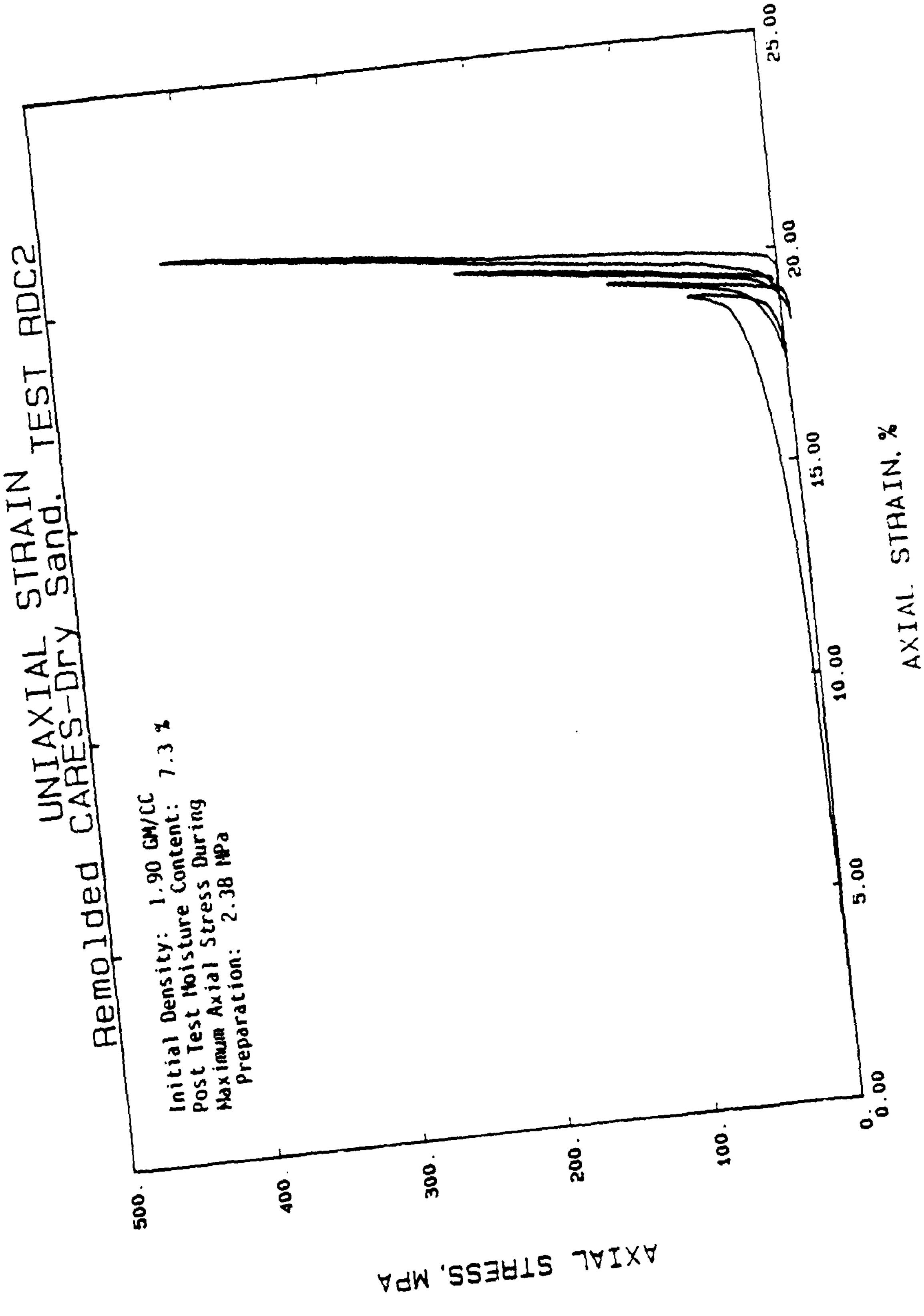
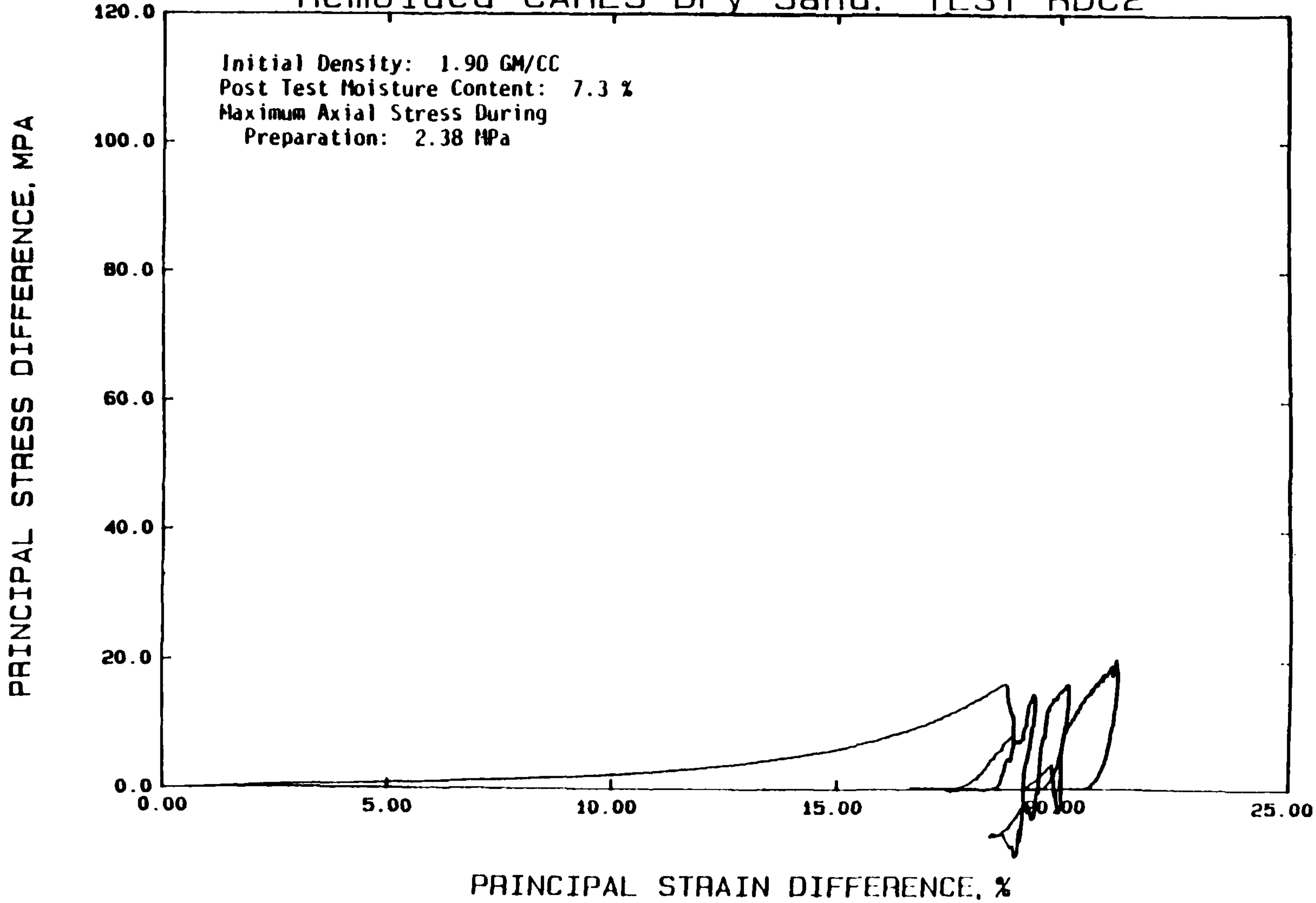

UNIAXIAL STRAIN
Remolded CARES-Dry Sand. TEST RDC2
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 7.3 %
Maximum Axial Stress During
Preparation: 2.38 MPa
AXIAL STRESS, MPA
AXIAL STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00
100.
200.
300.
400.
500.

Plate 28

UNIAXIAL STRAIN
Remolded CARES-Dry Sand. TEST RDC2



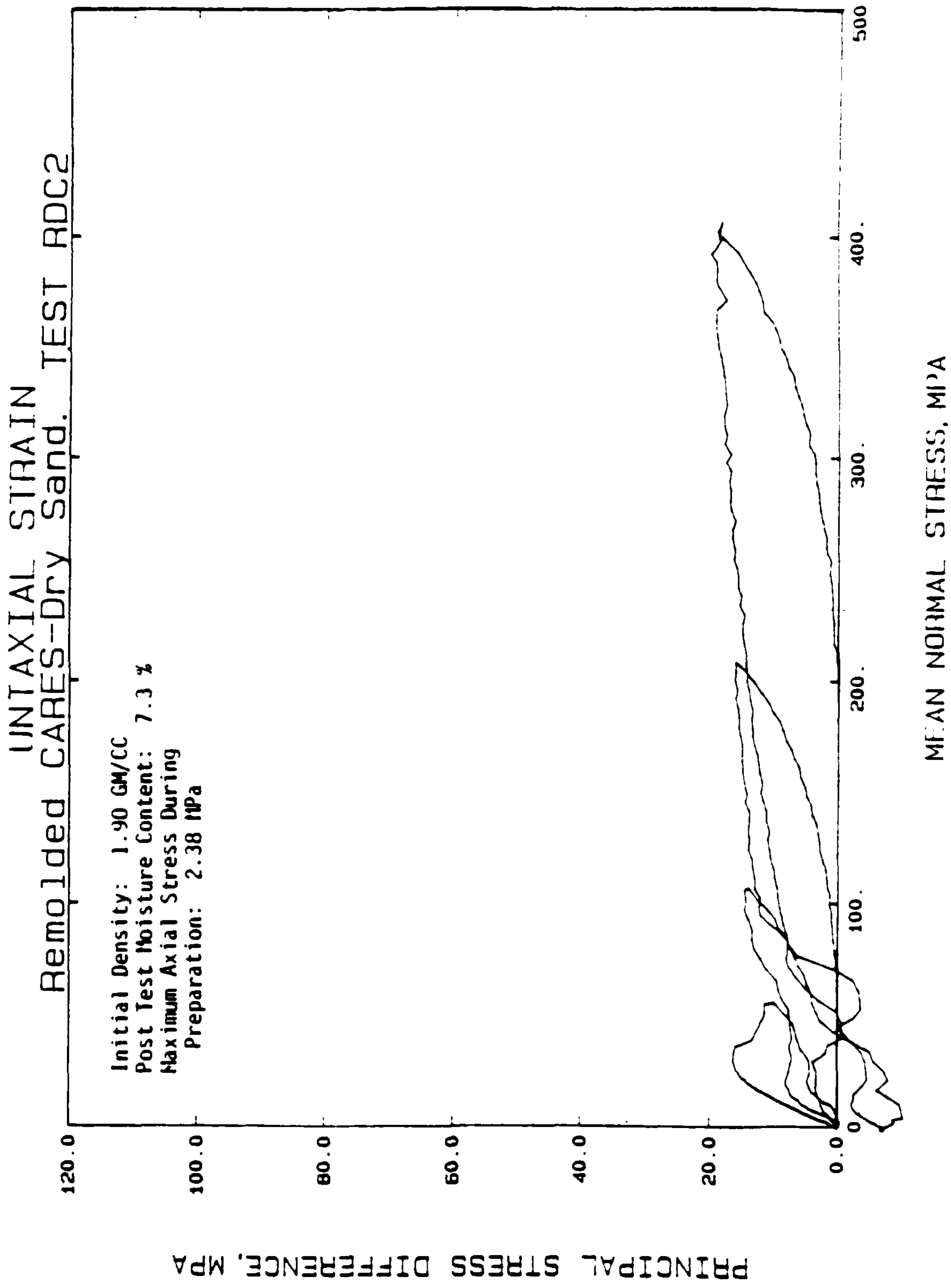
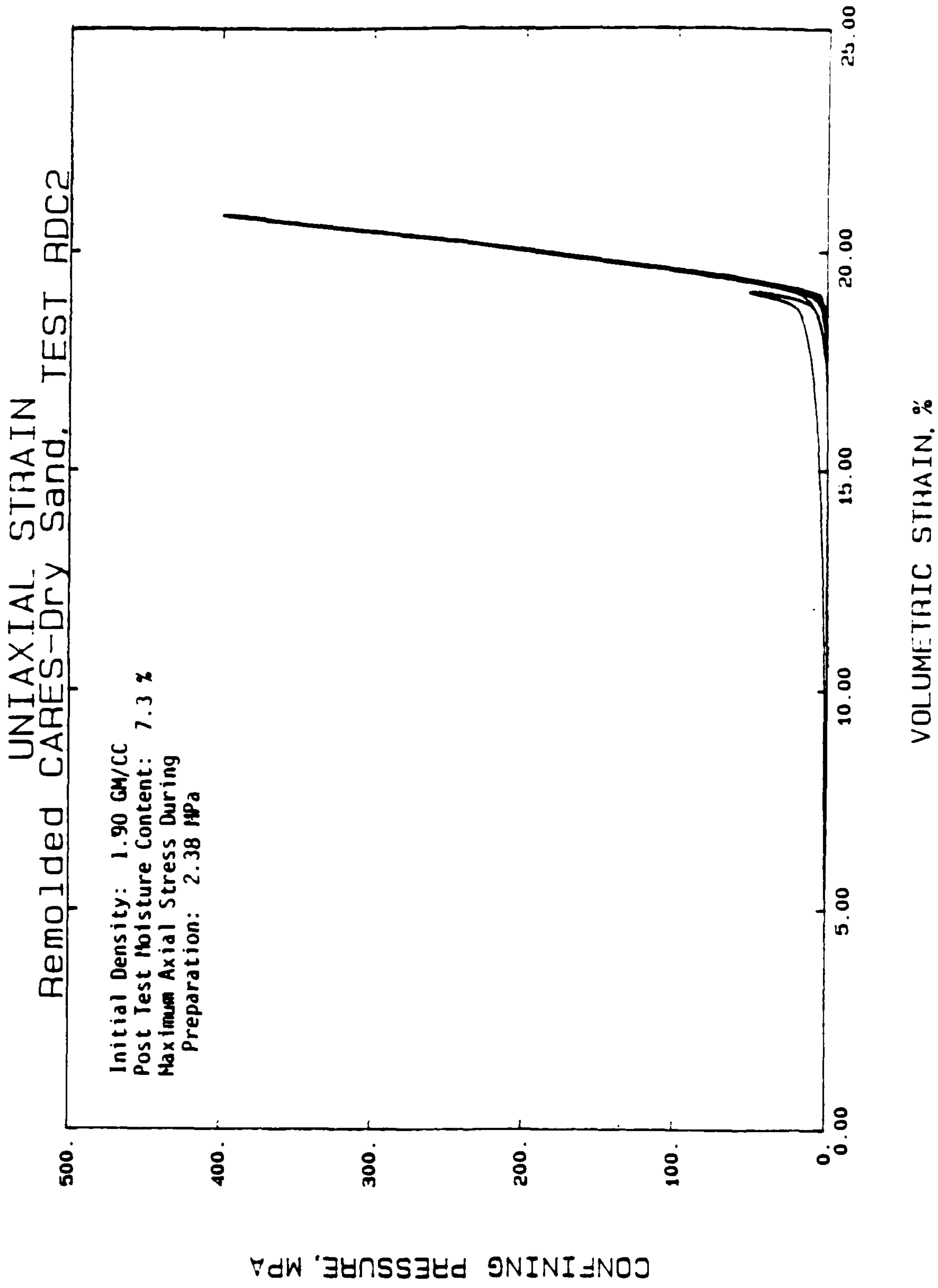

UNIAXIAL STRAIN
Remolded CARES-Dry Sand. TEST RDC2
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 7.3 %
Maximum Axial Stress During
Preparation: 2.38 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
100.
200.
300.
400.
500.
MEAN NORMAL STRESS, MPA

Plate 30



UNIAXIAL STRAIN
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 7.3 %
Maximum Axial Stress During
Preparation: 2.38 MPa
0.00
5.00
10.00
15.00
20.00
25.00
VOLUMETRIC STRAIN, %
0.
100.
200.
300.
400.
500.
CONFINING PRESSURE, MPA

Plate 31

UNIAXIAL STRAIN
Remolded CARES-Dry Sand, TEST RDC3

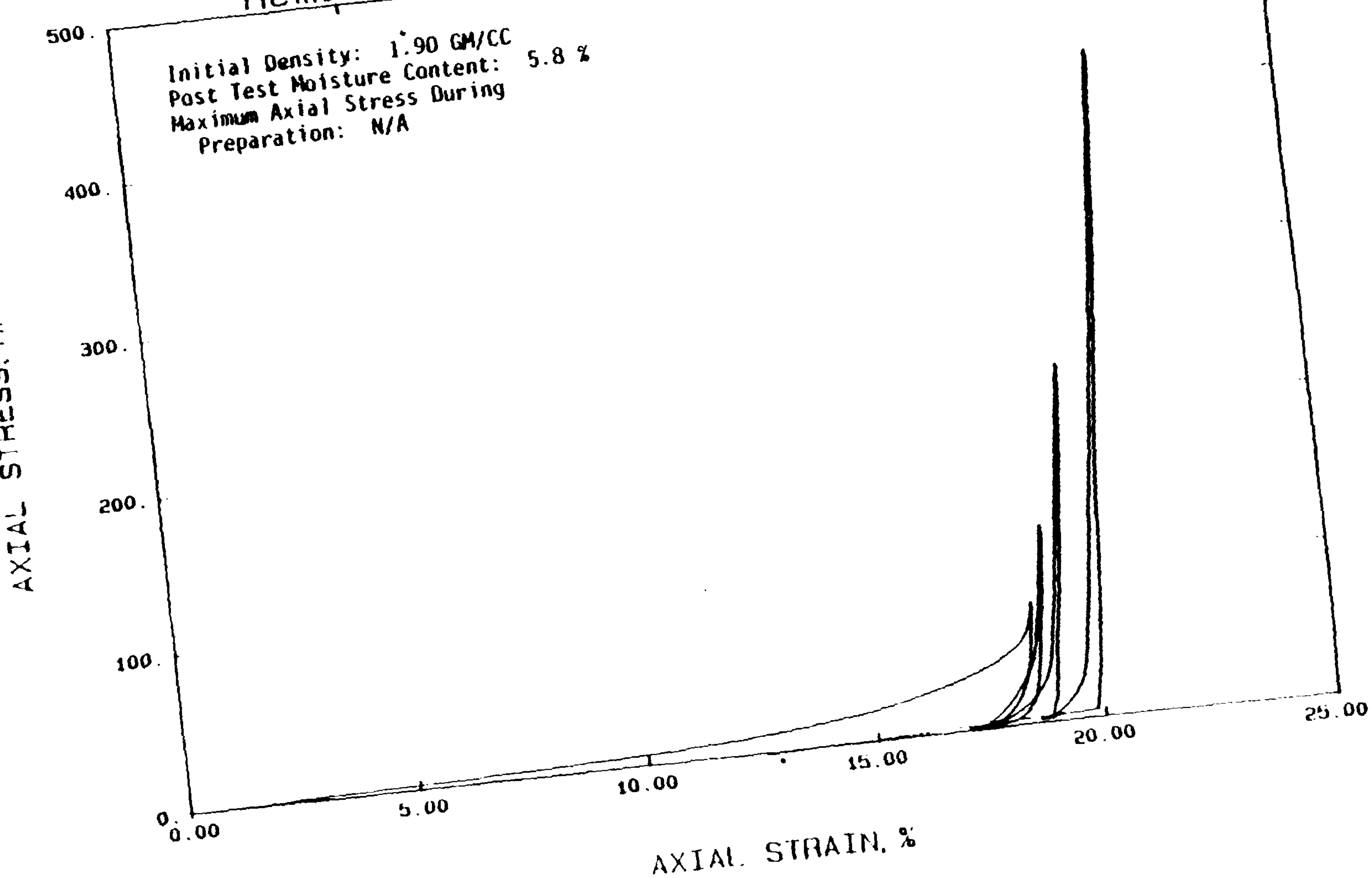
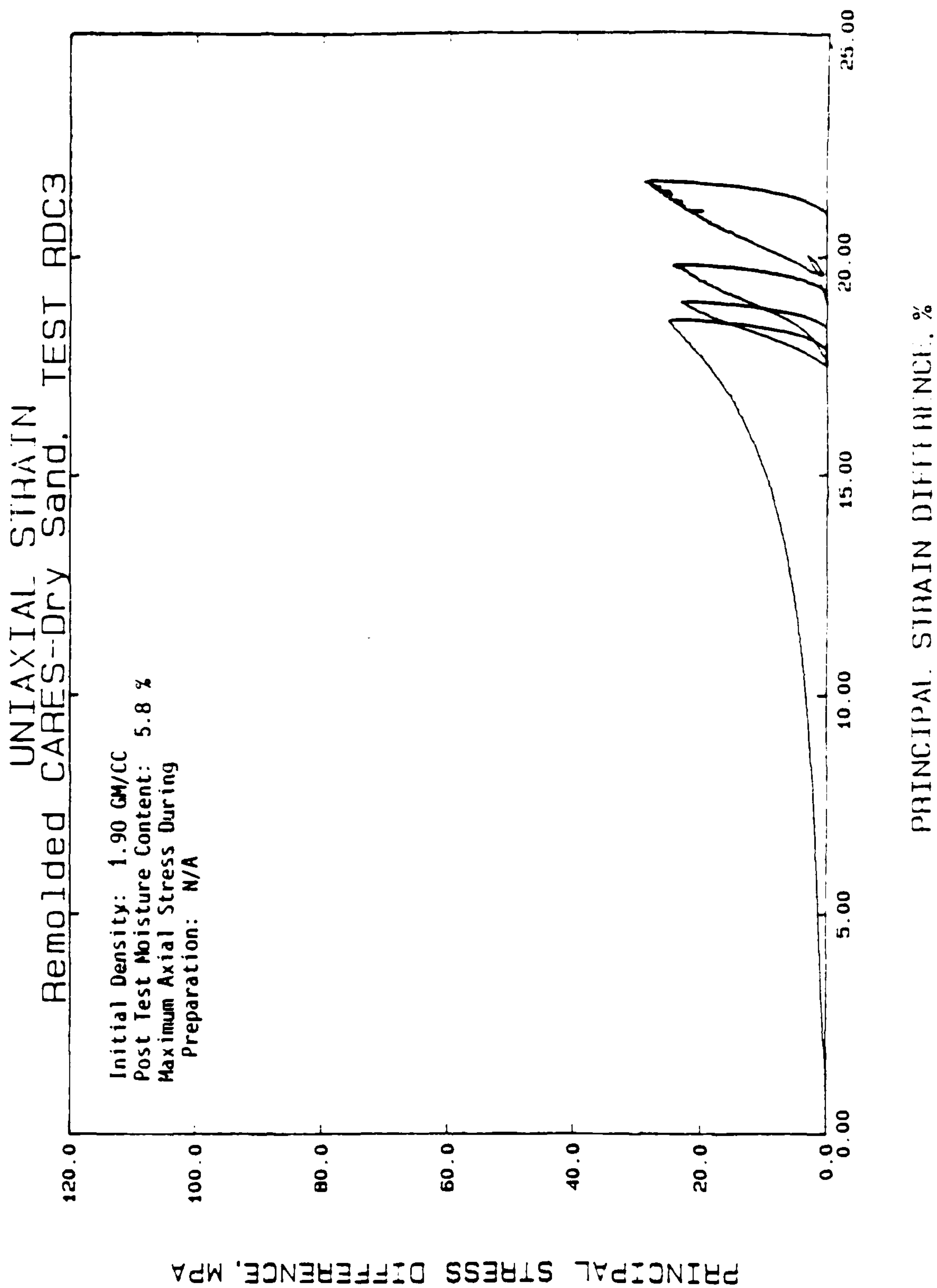


Plate 32



UNIAXIAL STRAIN
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 5.8 %
Maximum Axial Stress During
Preparation: N/A
PRINCIPAL STRESS DIFFERENCE, MPA
0.0
20.0
40.0
60.0
80.0
100.0
120.0
PRINCIPAL STRAIN DIFFERENCE, %
0.00
5.00
10.00
15.00
20.00
25.00

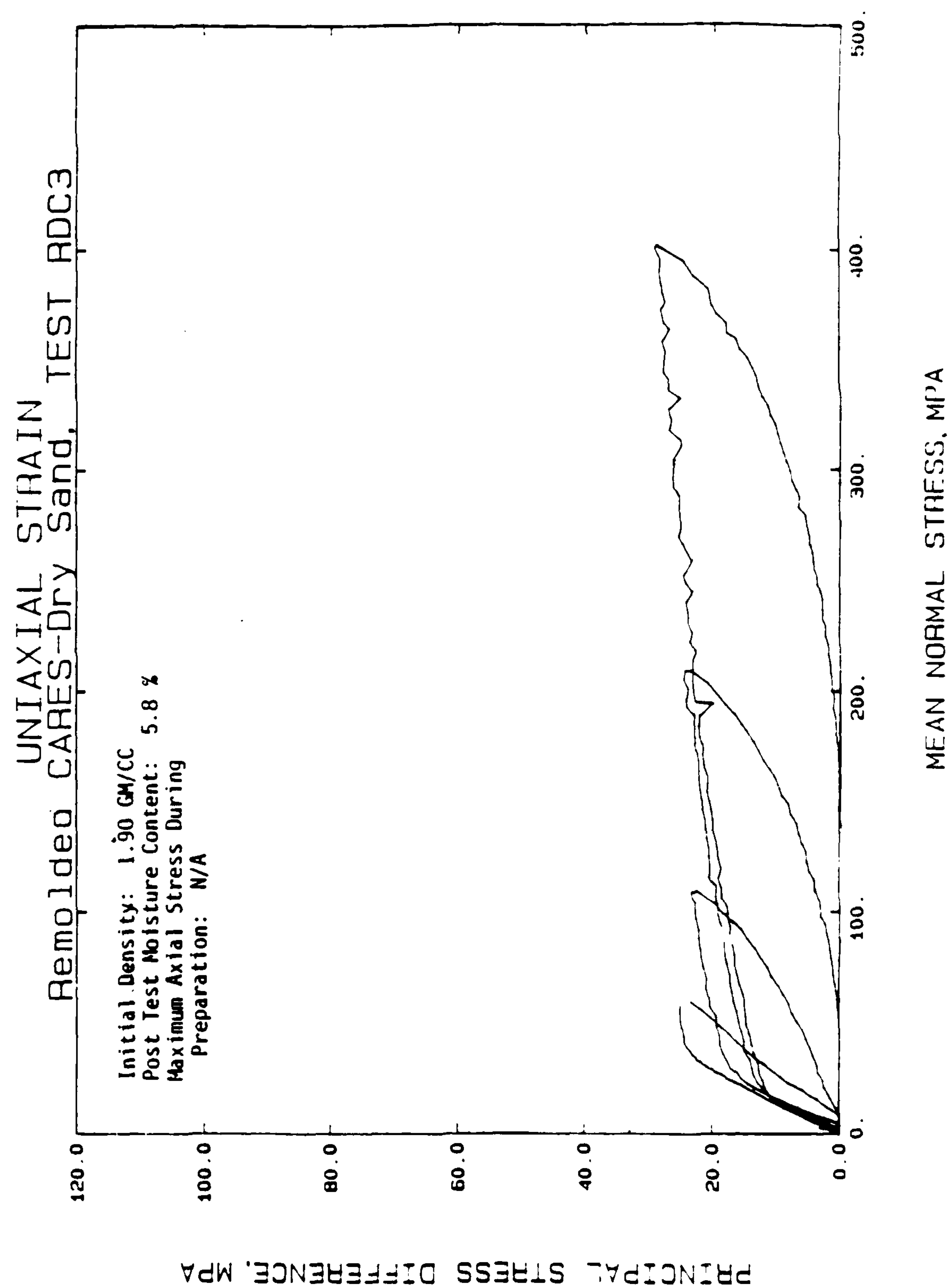

UNIAXIAL STRAIN
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 5.8 %
Maximum Axial Stress During
Preparation: N/A
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.
100.
200.
300.
400.
500.
MEAN NORMAL STRESS, MPA
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 34

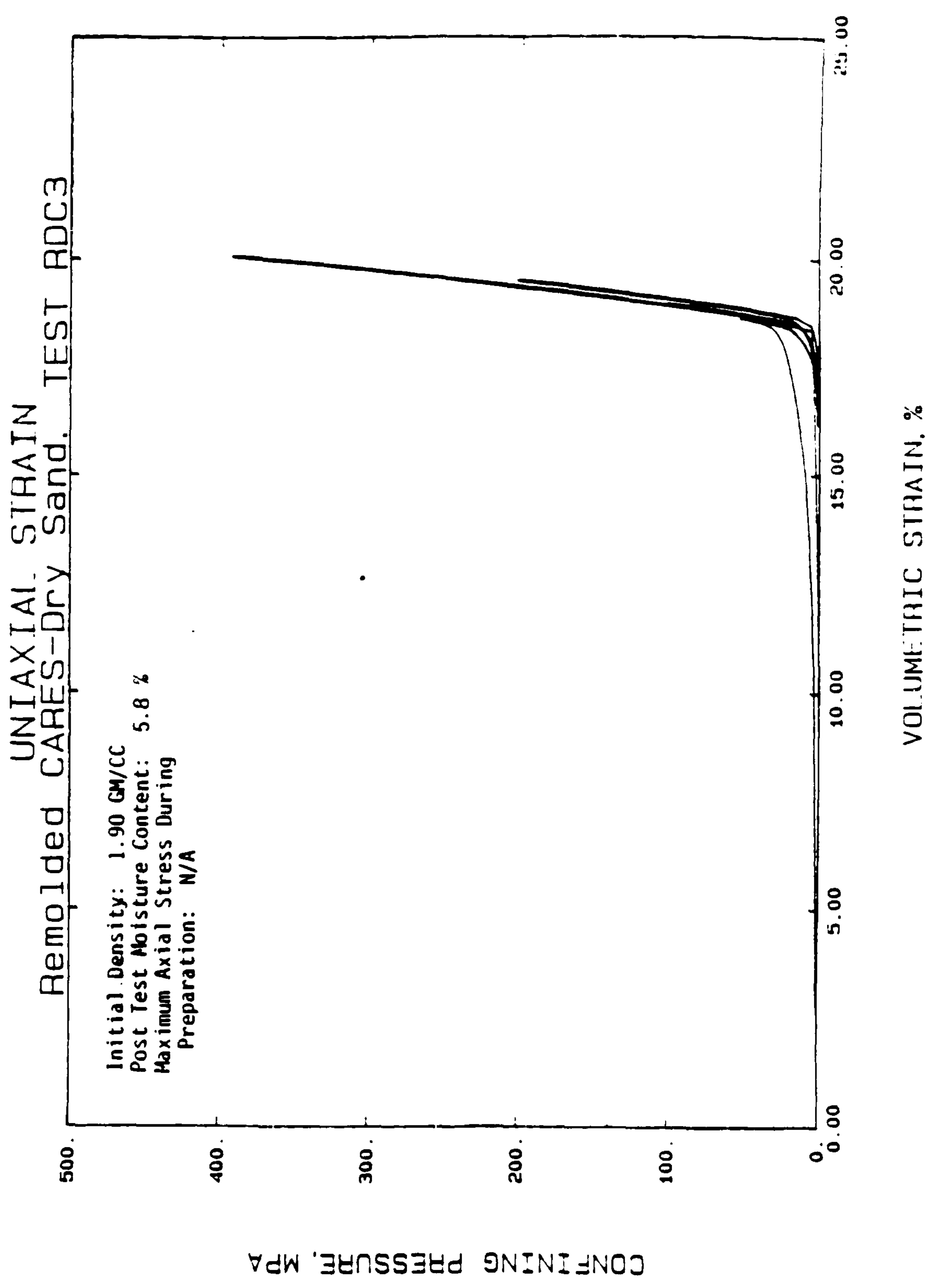

UNIAXIAL STRAIN
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.90 GM/CC
Post Test Moisture Content: 5.8 %
Maximum Axial Stress During
Preparation: N/A
CONFINING PRESSURE, MPA
VOLUMETRIC STRAIN, %
0.
100.
200.
300.
400.
500.
0.00
5.00
10.00
15.00
20.00

Plate 35

UNIAXIAL STRAIN

Undisturbed CARES-Dry Sand, TEST UDC1

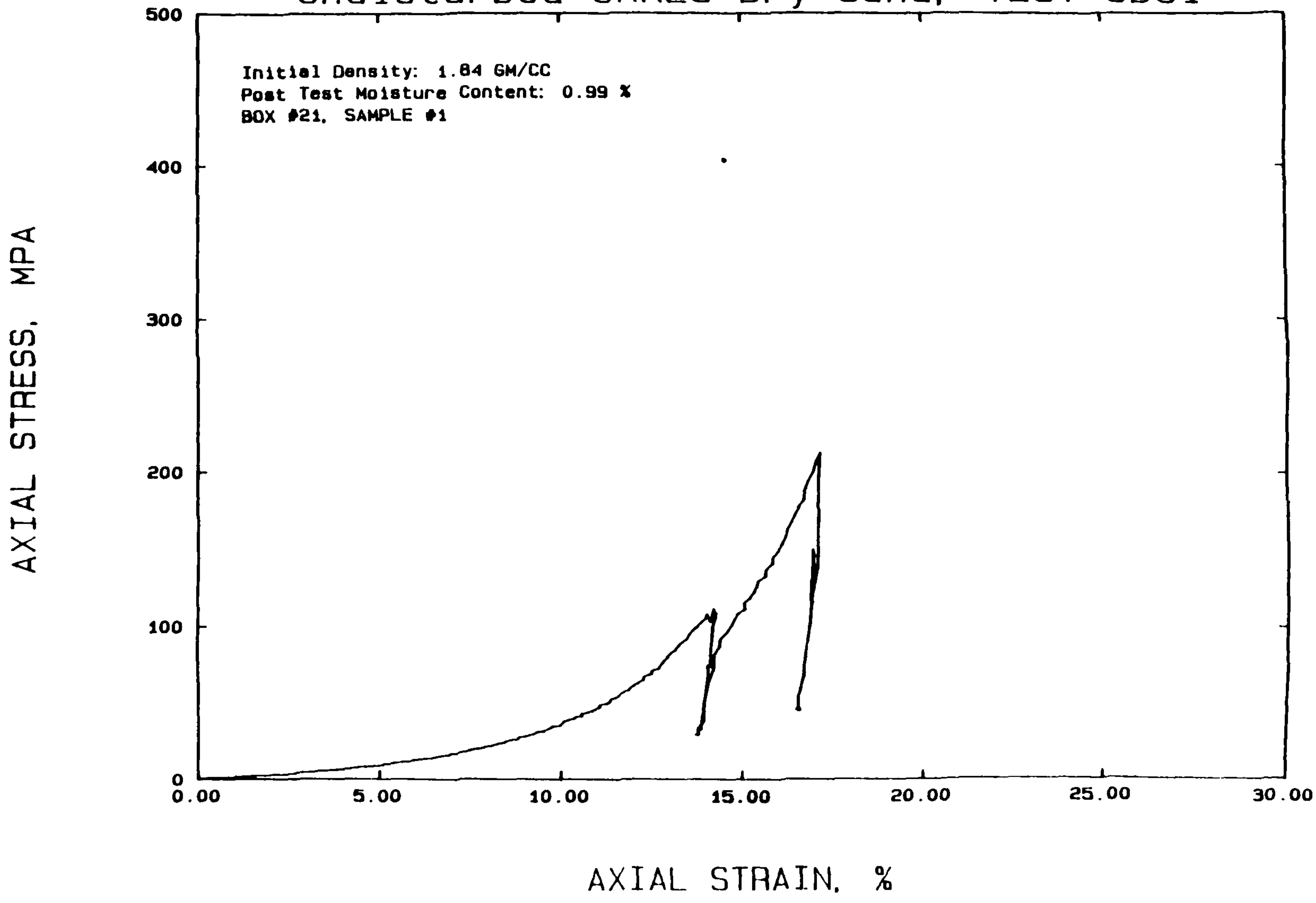
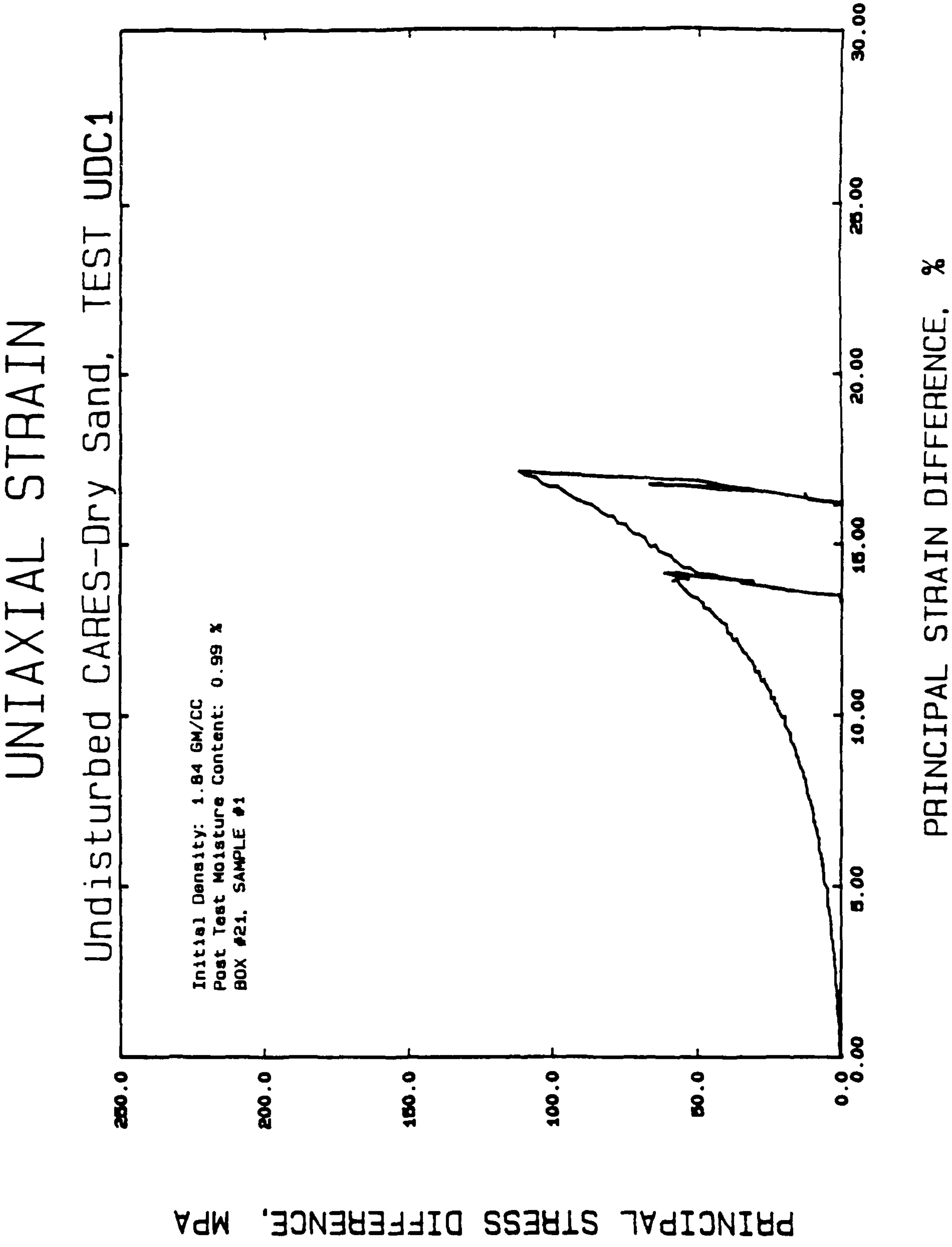


Plate 36


UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC1
Initial Density: 1.84 GM/CC
Post Test Moisture Content: 0.99 %
BOX #21, SAMPLE #1
PRINCIPAL STRESS DIFFERENCE, MPA
0.0
50.0
100.0
150.0
200.0
250.0
PRINCIPAL STRAIN DIFFERENCE, %
0.00
5.00
10.00
15.00
20.00
25.00
30.00

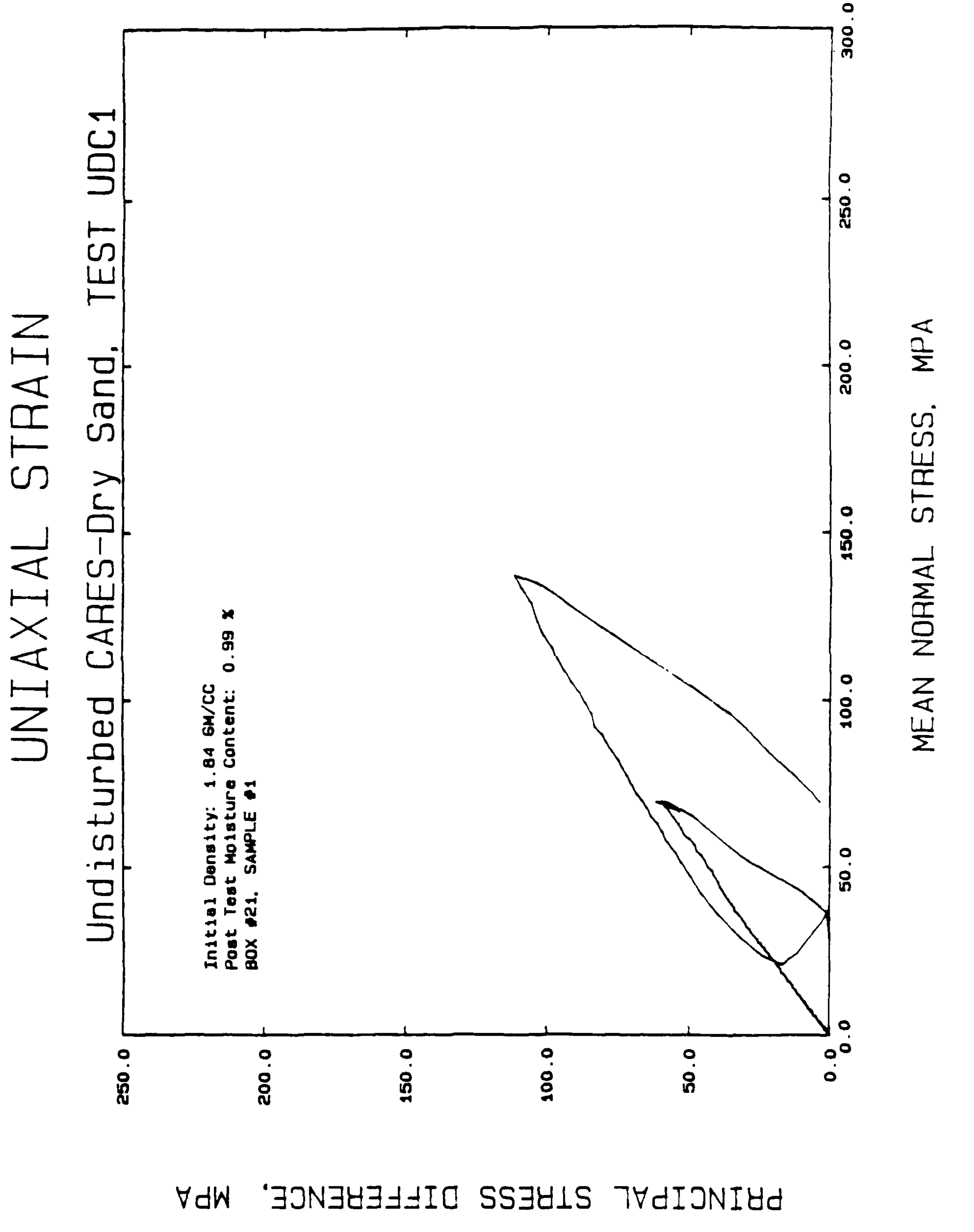
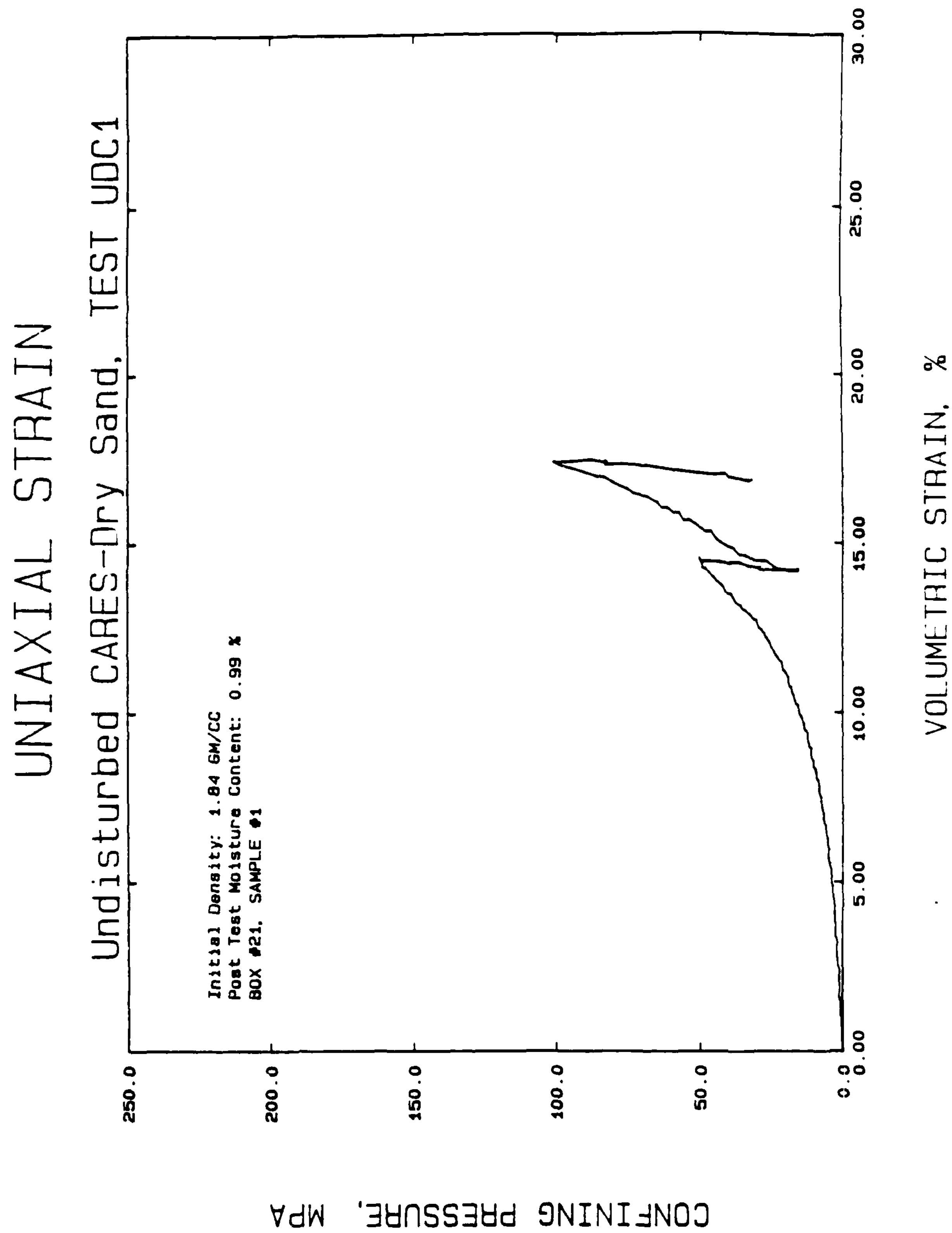
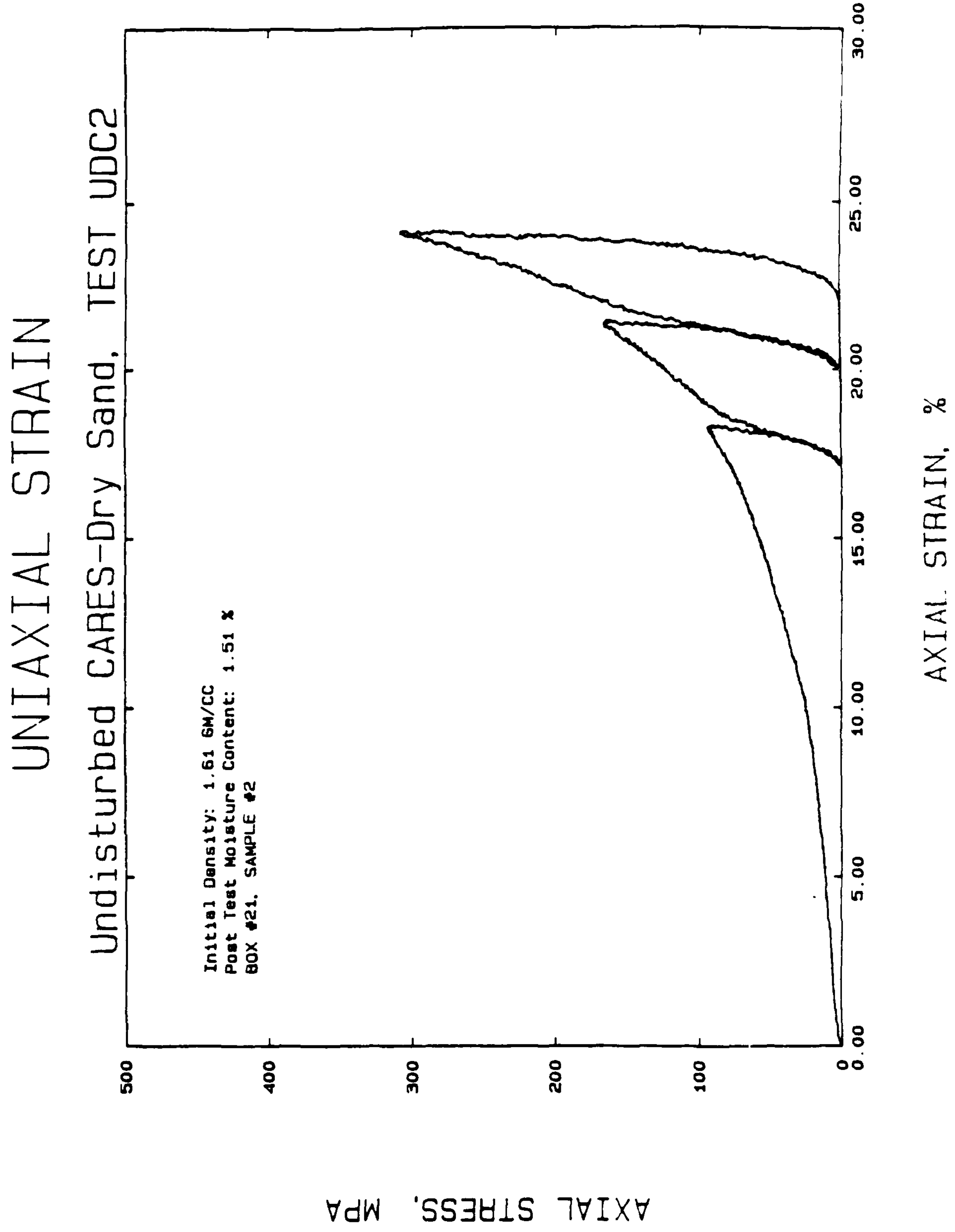

UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC1
Initial Density: 1.84 GM/CC
Post Test Moisture Content: 0.99 %
BOX #21, SAMPLE #1
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
0.0
50.0
100.0
150.0
200.0
250.0
300.0

Plate 38



UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC1
Initial Density: 1.84 GM/CC
Post Test Moisture Content: 0.99 %
BOX #21, SAMPLE #1
0.0
50.0
100.0
150.0
200.0
250.0
CONFINING PRESSURE, MPA
0.00
5.00
10.00
15.00
20.00
25.00
30.00
VOLUMETRIC STRAIN, %

Plate 39



UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC2
Initial Density: 1.61 GM/CC
Post Test Moisture Content: 1.51 %
BOX #21, SAMPLE #2
0.00
5.00
10.00
15.00
20.00
25.00
30.00
AXIAL STRAIN, %
0
100
200
300
400
500
AXIAL STRESS, MPA

Plate 40

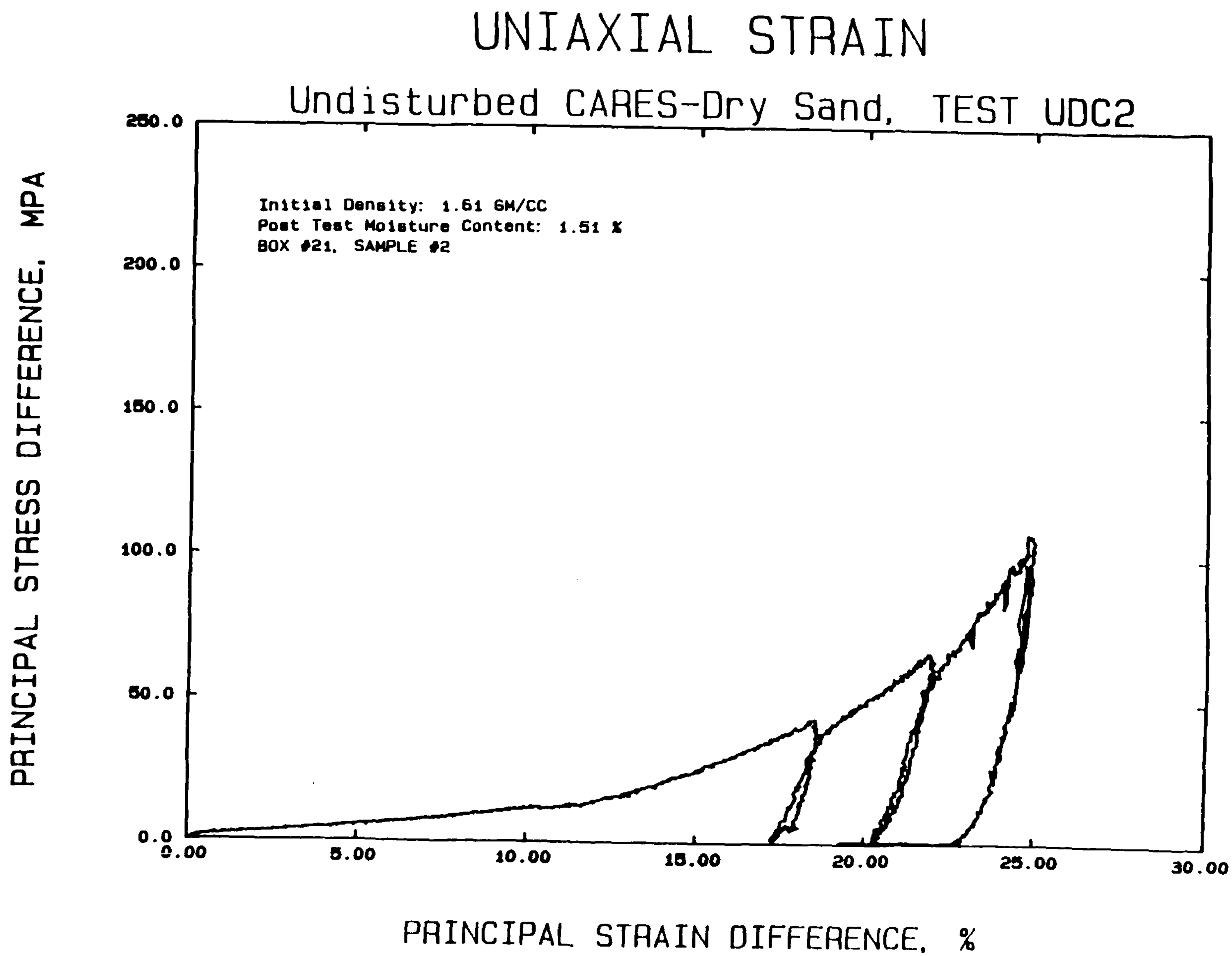

UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC2
Initial Density: 1.61 GM/CC
Post Test Moisture Content: 1.51 %
BOX #21, SAMPLE #2
250.0
200.0
150.0
100.0
50.0
0.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %

Plate 41

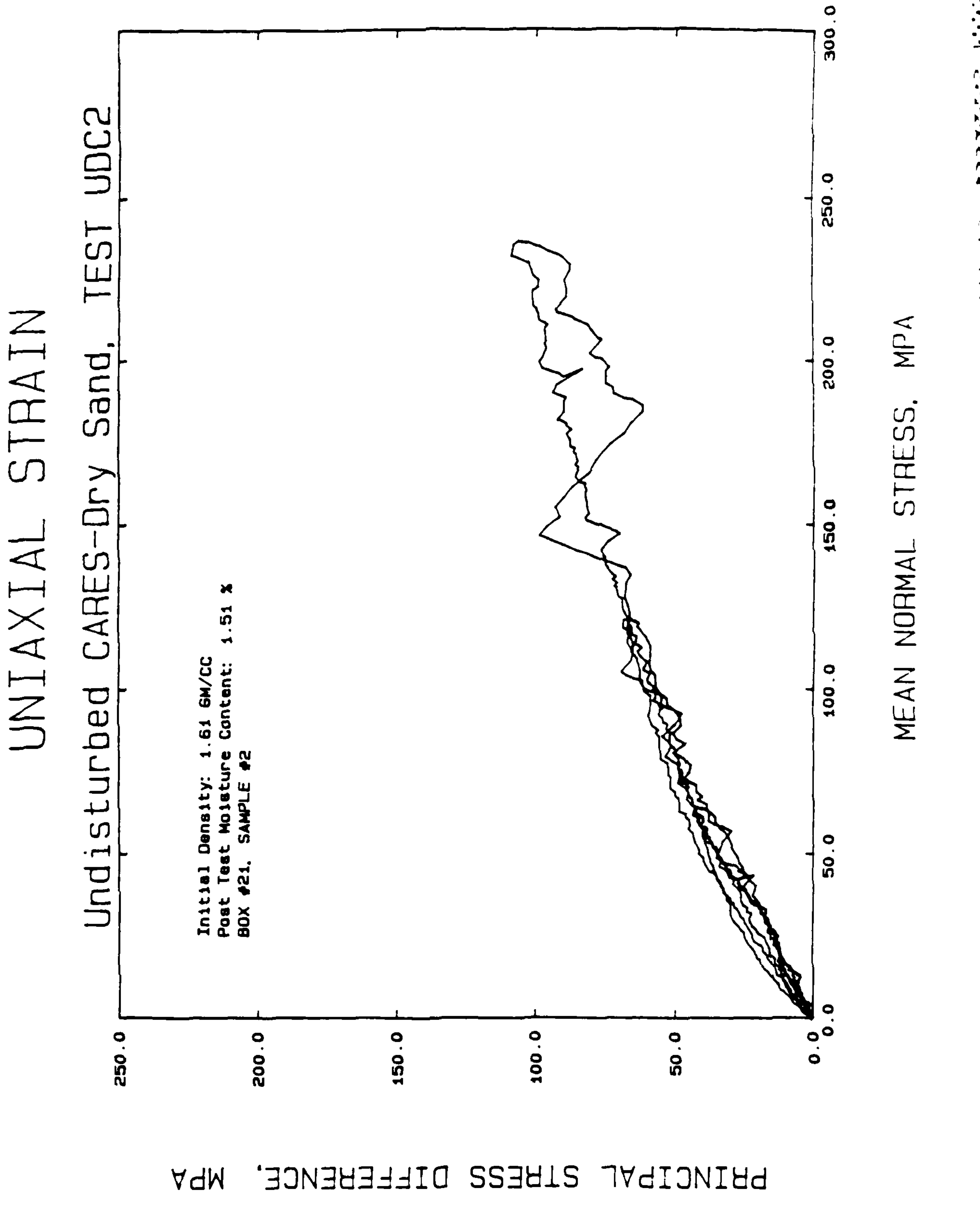
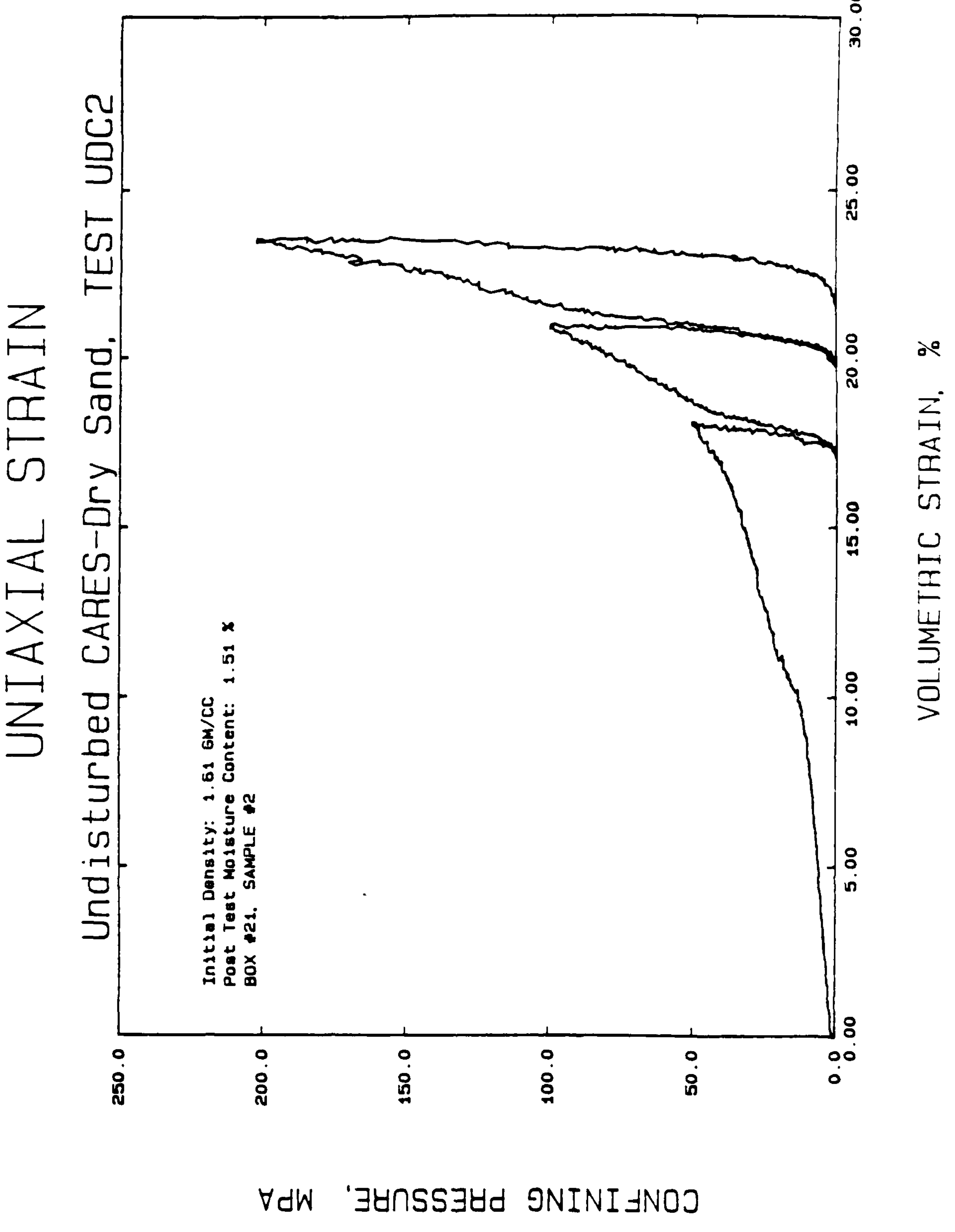

UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC2
Initial Density: 1.61 GM/CC
Post Test Moisture Content: 1.51 %
BOX #21, SAMPLE #2
0.0
50.0
100.0
150.0
200.0
250.0
300.0
MEAN NORMAL STRESS, MPA
0.0
50.0
100.0
150.0
200.0
250.0
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 42



UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC2
Initial Density: 1.61 GM/CC
Post Test Moisture Content: 1.51 %
BOX #21, SAMPLE #2
CONFINING PRESSURE, MPA
0.0
50.0
100.0
150.0
200.0
250.0
VOLUMETRIC STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 43

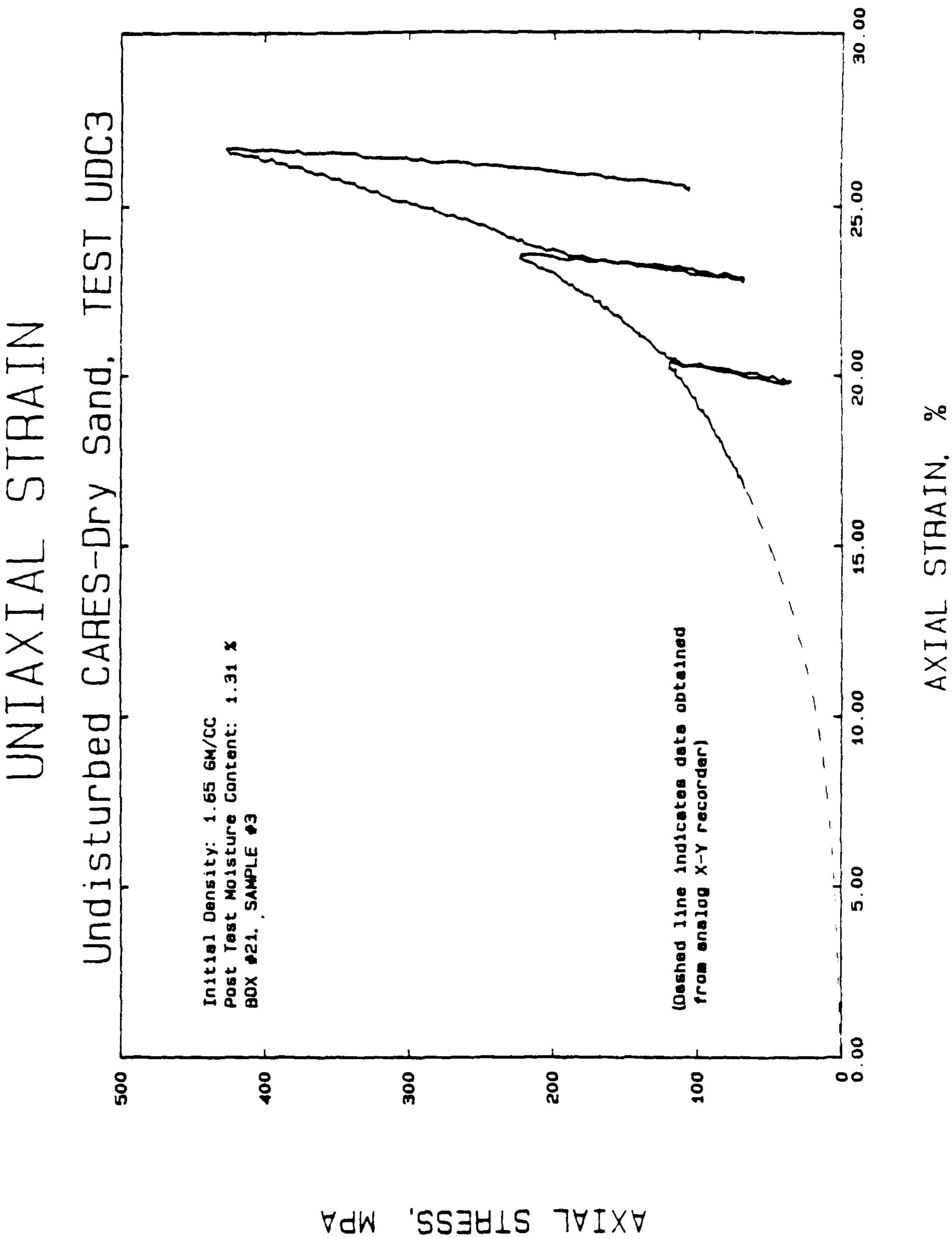
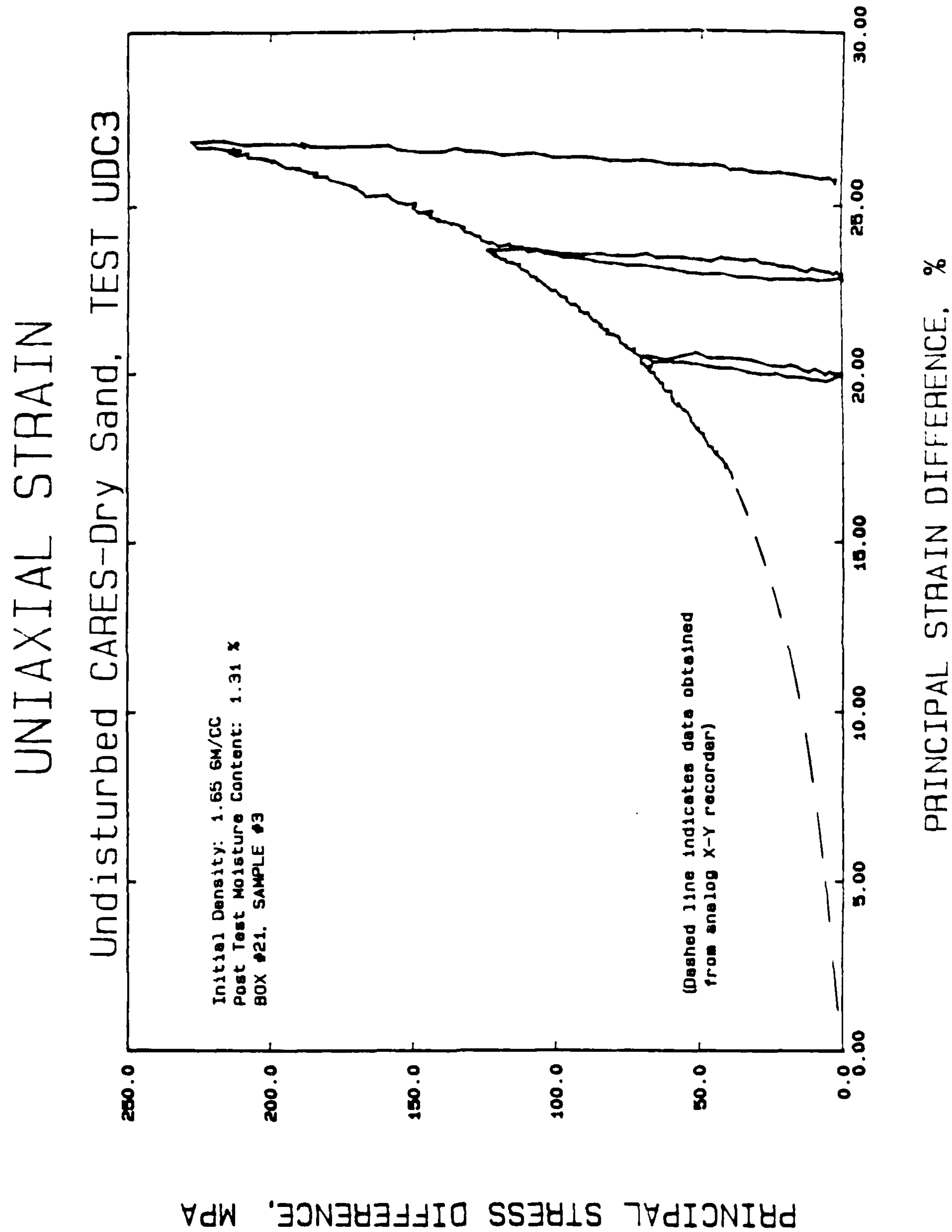
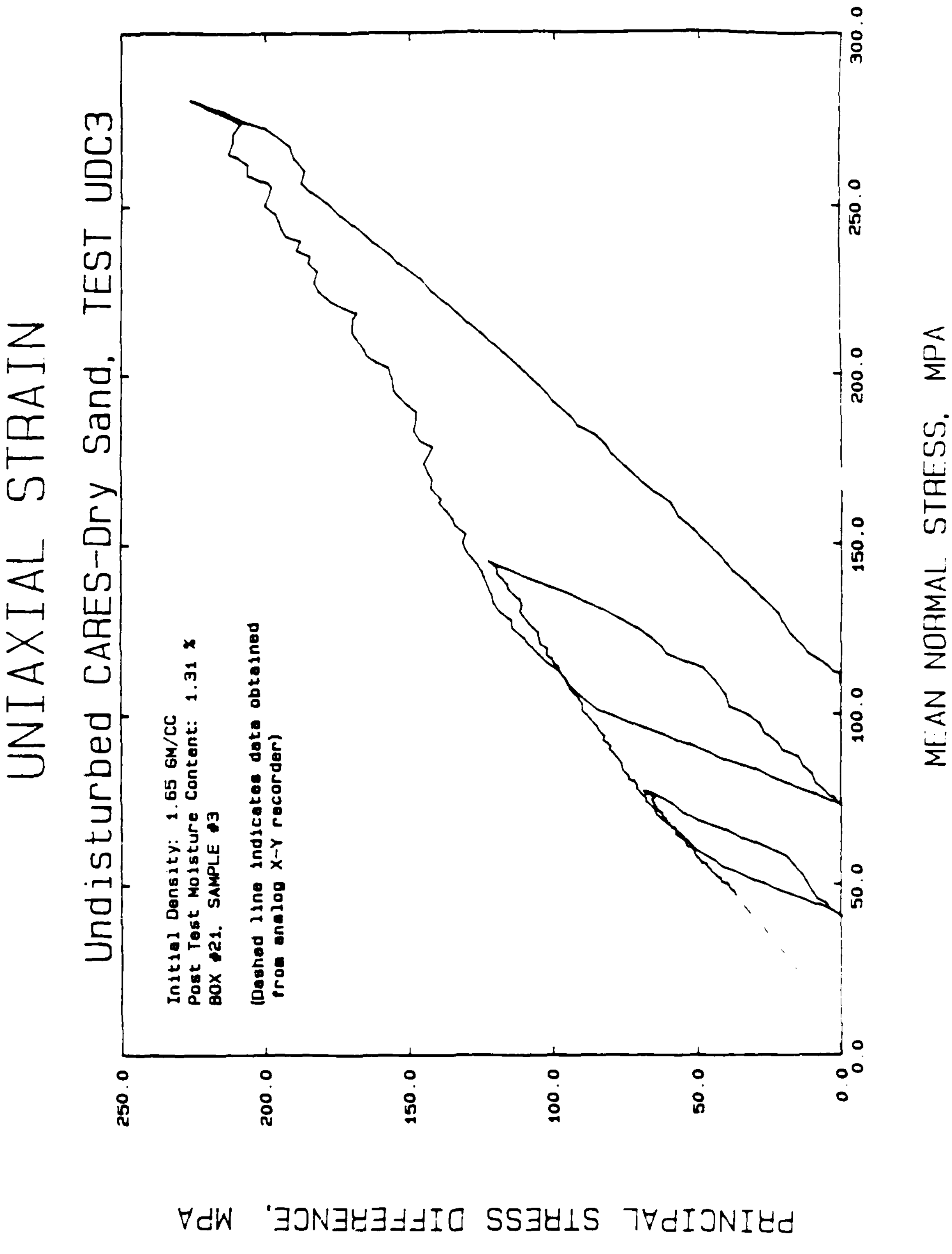

UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC3
Initial Density: 1.65 GM/CC
Post Test Moisture Content: 1.31 %
BOX #21, SAMPLE #3
(Dashed line indicates data obtained from analog X-Y recorder)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
AXIAL STRAIN, %
0
100
200
300
400
500
AXIAL STRESS, MPA

Plate 44


UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC3
Initial Density: 1.65 GM/CC
Post Test Moisture Content: 1.31 %
BOX #21, SAMPLE #3
(Dashed line indicates data obtained
from analog X-Y recorder)
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
0.0
50.0
100.0
150.0
200.0
250.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00



UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC3
Initial Density: 1.65 GM/CC
Post Test Moisture Content: 1.31 %
BOX #21, SAMPLE #3
(Dashed line indicates data obtained from analog X-Y recorder)
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
0.0
50.0
100.0
150.0
200.0
250.0
300.0

Plate 46

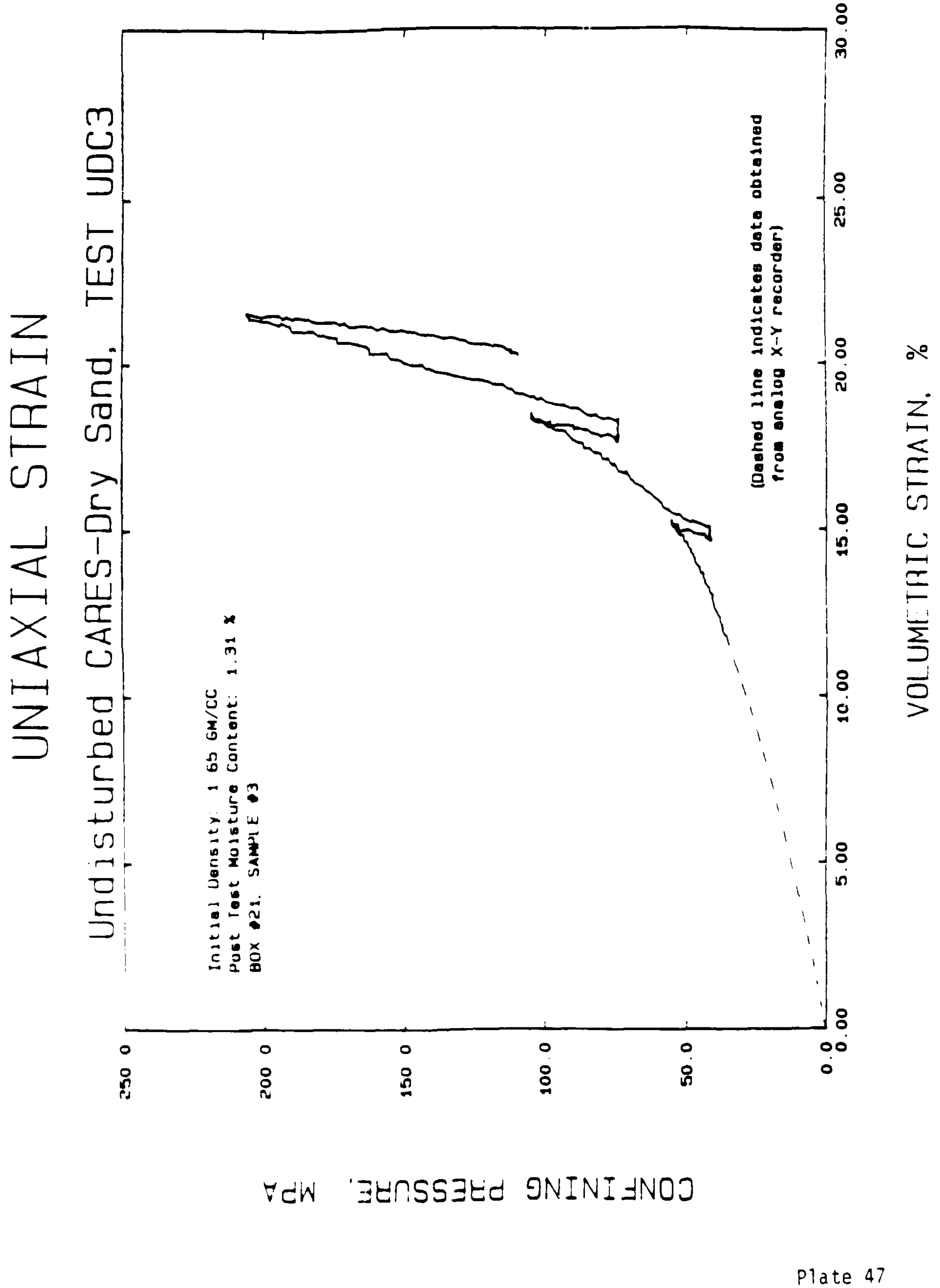
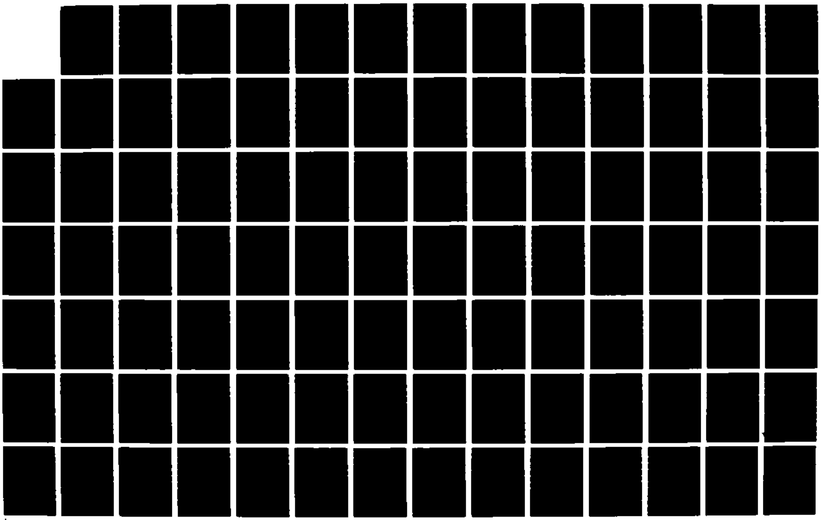
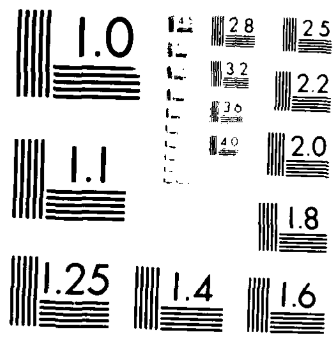

UNIAXIAL STRAIN
Undisturbed CARES-Dry Sand, TEST UDC3
Initial Density: 1.65 GM/CC
Post Test Moisture Content: 1.31 %
BOX #21, SAMPLE #3
(Dashed line indicates data obtained
from analog X-Y recorder)
CONFINING PRESSURE, MPA
VOLUMETRIC STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 47

AD-A180 755 MECHANICAL PROPERTIES OF ALLUVIUM FROM NELLIS AIR FORCE RANGE NEVADA; LUK..(U) TERRA TEK INC SALT LAKE CITY UT J B WANGSGARD ET AL. 14 OCT 86 TR-86-76 DNA-TR-87-60 2/4

UNCLASSIFIED DNA001-83-C-0193 F/G 8/10 NL




1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

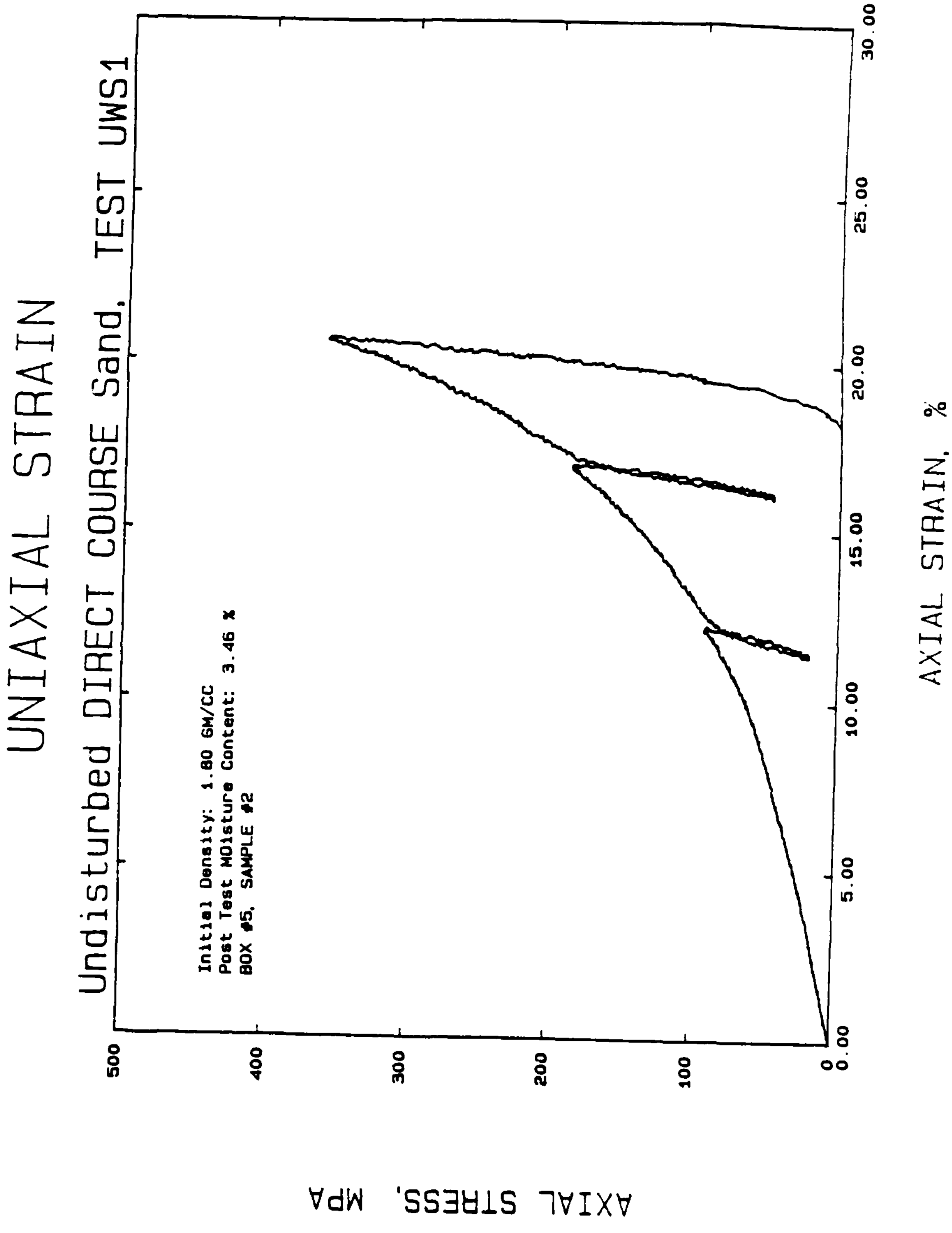
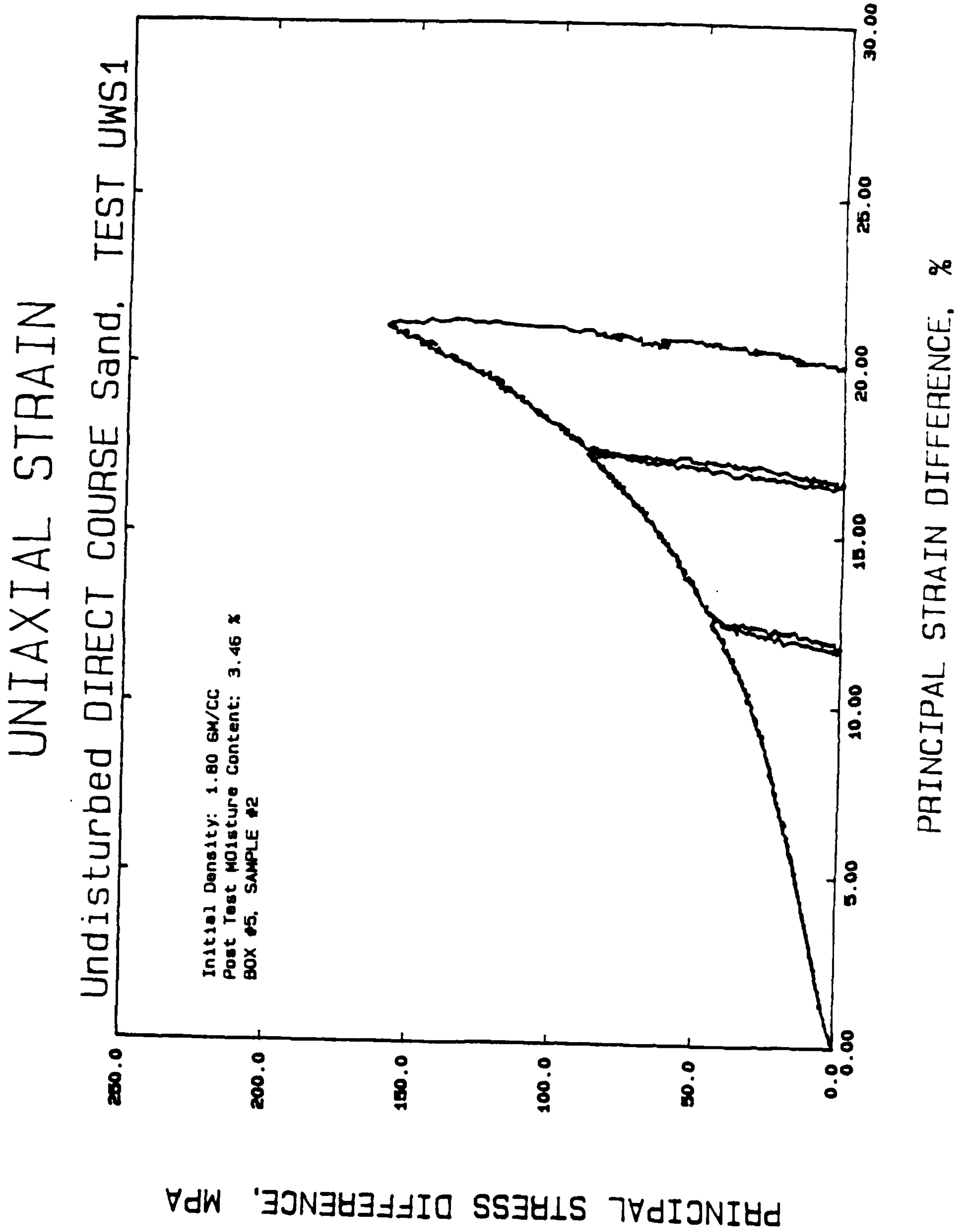

UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS1
Initial Density: 1.80 GM/CC
Post Test MOisture Content: 3.46 %
BOX #5, SAMPLE #2
AXIAL STRESS, MPA
0
100
200
300
400
500
AXIAL STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 48



UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS1
Initial Density: 1.80 GM/CC
Post Test MOisture Content: 3.46 %
BOX #5, SAMPLE #2
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
0.0
50.0
100.0
150.0
200.0
250.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 49

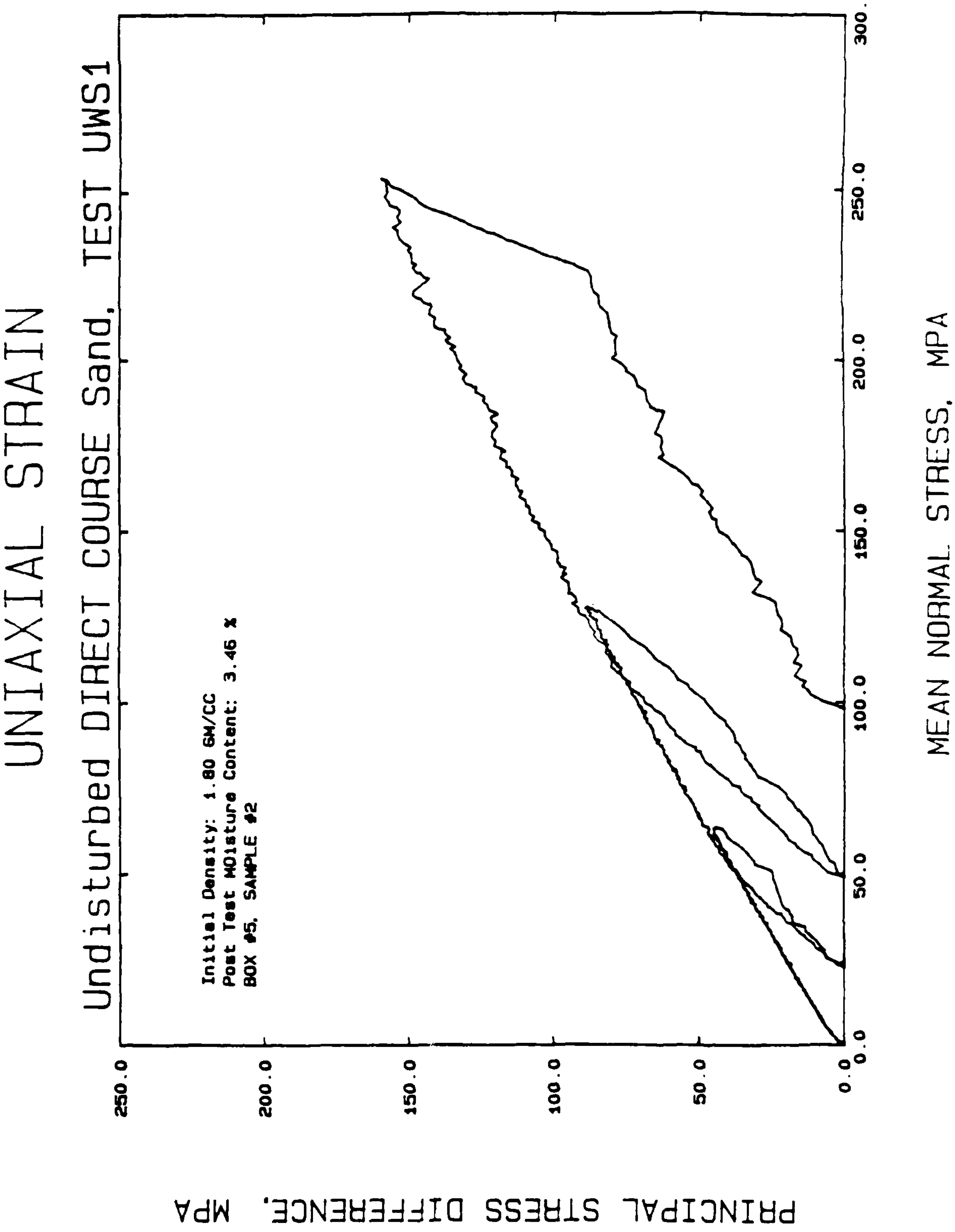
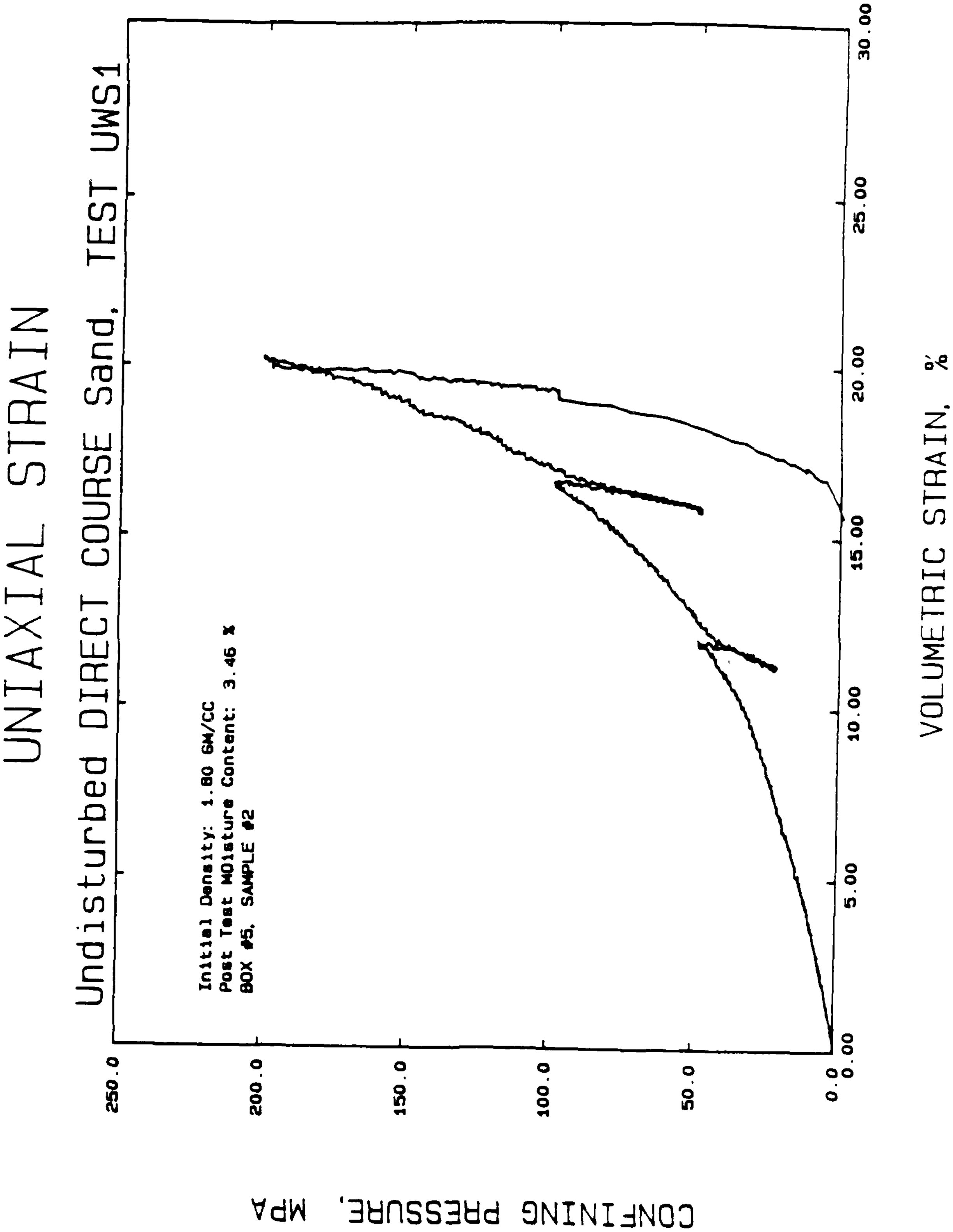
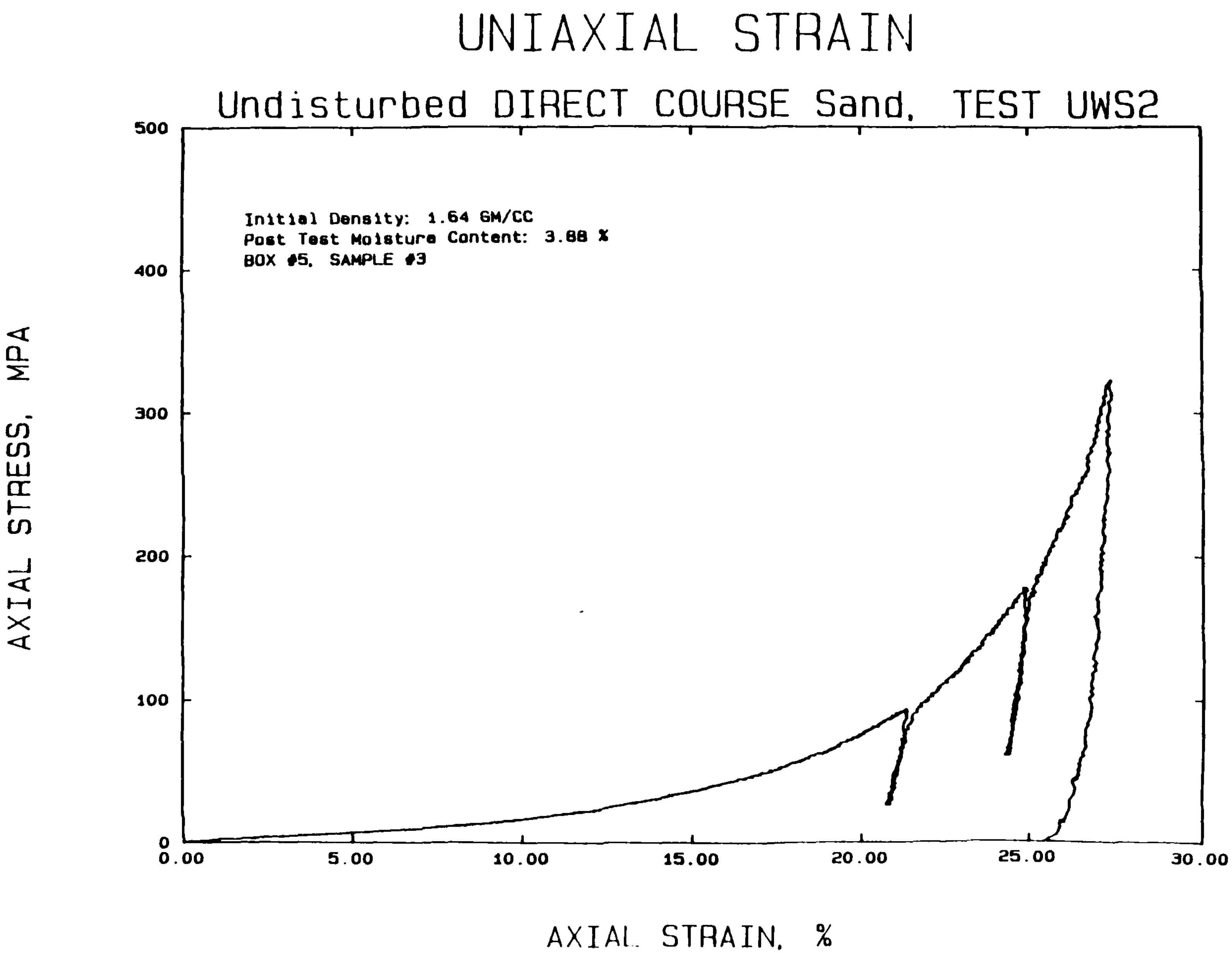

UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS1
Initial Density: 1.80 GM/CC
Post Test MOisture Content: 3.46 %
BOX #5, SAMPLE #2
0.0
50.0
100.0
150.0
200.0
250.0
300.0
MEAN NORMAL STRESS, MPA
0.0
50.0
100.0
150.0
200.0
250.0
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 50



UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS1
Initial Density: 1.80 GM/CC
Post Test MOisture Content: 3.46 %
BOX #5, SAMPLE #2
0.0
50.0
100.0
150.0
200.0
250.0
CONFINING PRESSURE, MPA
0.00
5.00
10.00
15.00
20.00
25.00
30.00
VOLUMETRIC STRAIN, %



UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS2
Initial Density: 1.64 GM/CC
Post Test Moisture Content: 3.88 %
BOX #5, SAMPLE #3
AXIAL STRESS, MPA
0
100
200
300
400
500
0.00
5.00
10.00
15.00
20.00
25.00
30.00
AXIAL STRAIN, %

Plate 52

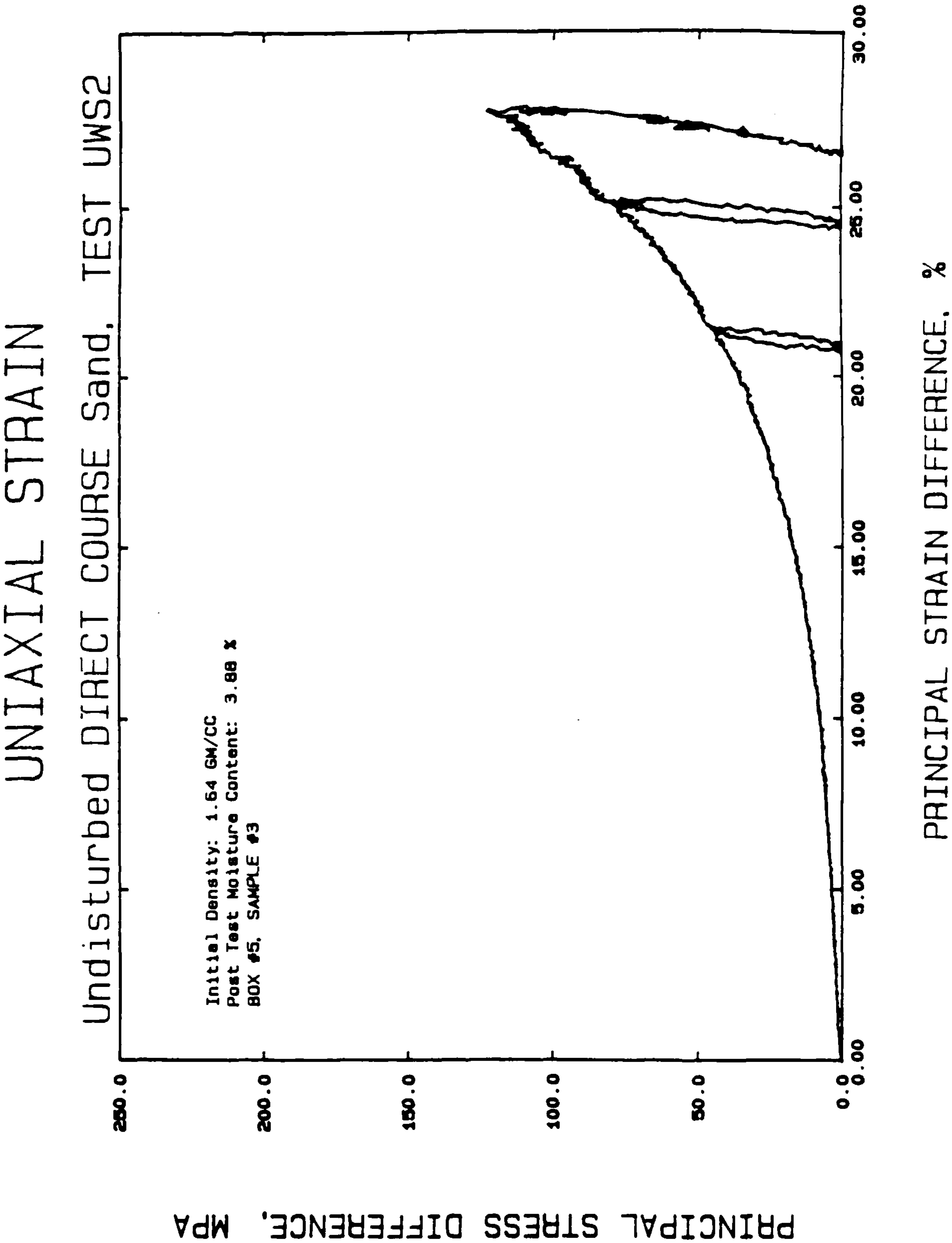

UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS2
Initial Density: 1.64 GM/CC
Post Test Moisture Content: 3.88 %
BOX #5, SAMPLE #3
PRINCIPAL STRESS DIFFERENCE, MPA
0.0
50.0
100.0
150.0
200.0
250.0
PRINCIPAL STRAIN DIFFERENCE, %
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 53

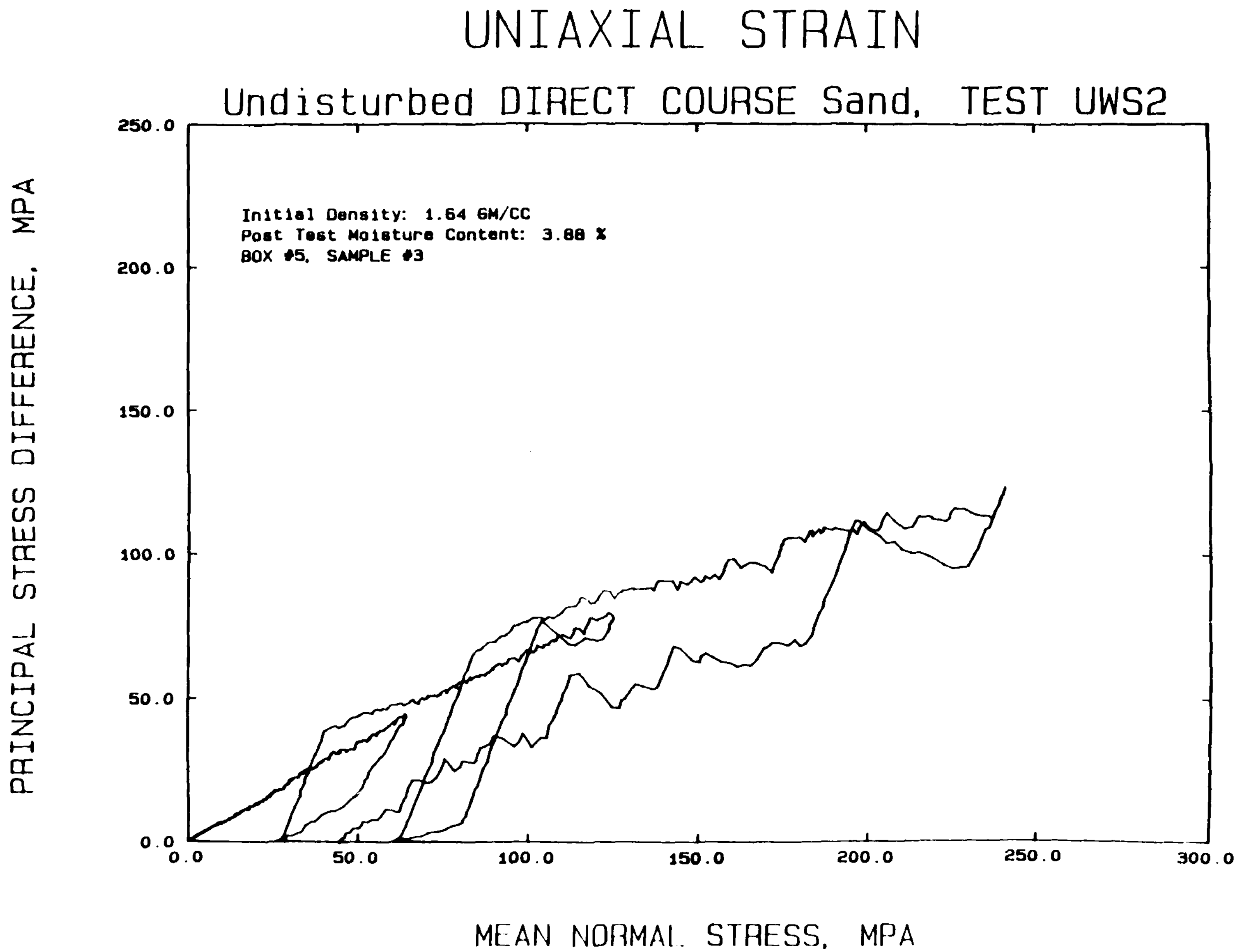
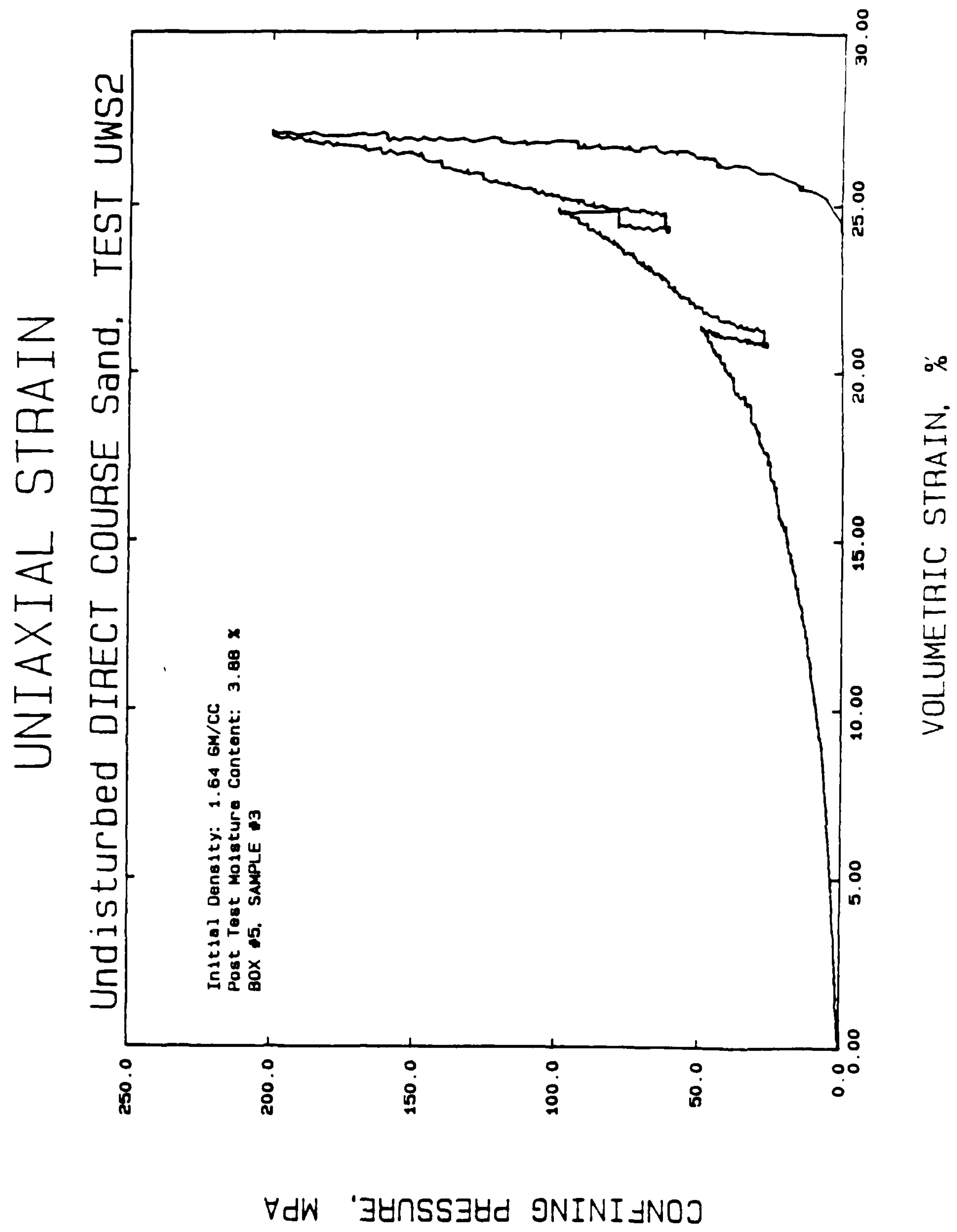

UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS2
Initial Density: 1.64 GM/CC
Post Test Moisture Content: 3.88 %
BOX #5, SAMPLE #3
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
0.0
50.0
100.0
150.0
200.0
250.0
300.0

Plate 54



UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS2
Initial Density: 1.64 GM/CC
Post Test Moisture Content: 3.88 %
BOX #5, SAMPLE #3
CONFINING PRESSURE, MPA
VOLUMETRIC STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 55

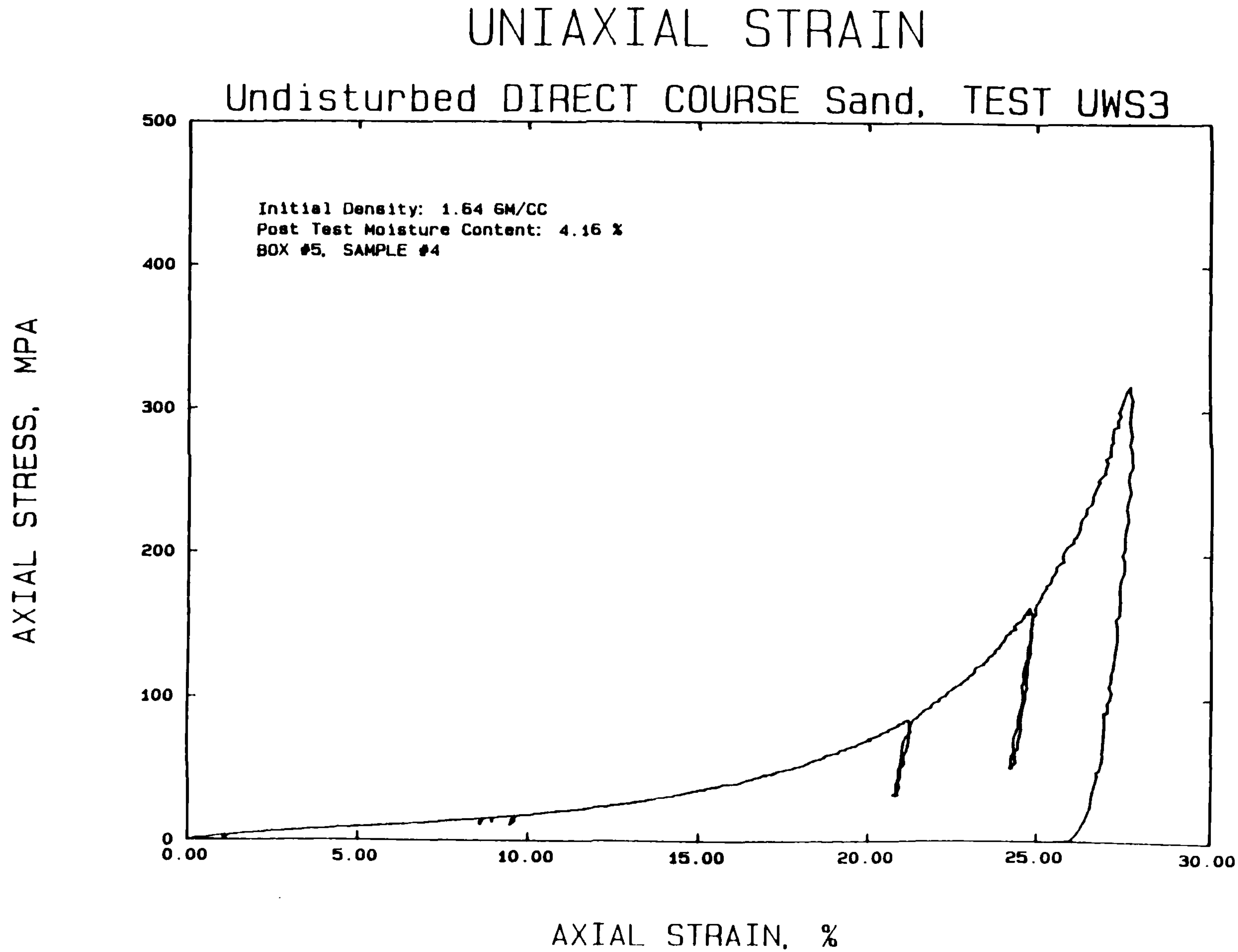

UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS3
Initial Density: 1.64 GM/CC
Post Test Moisture Content: 4.16 %
BOX #5, SAMPLE #4
AXIAL STRESS, MPA
AXIAL STRAIN, %
0
100
200
300
400
500
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Plate 56

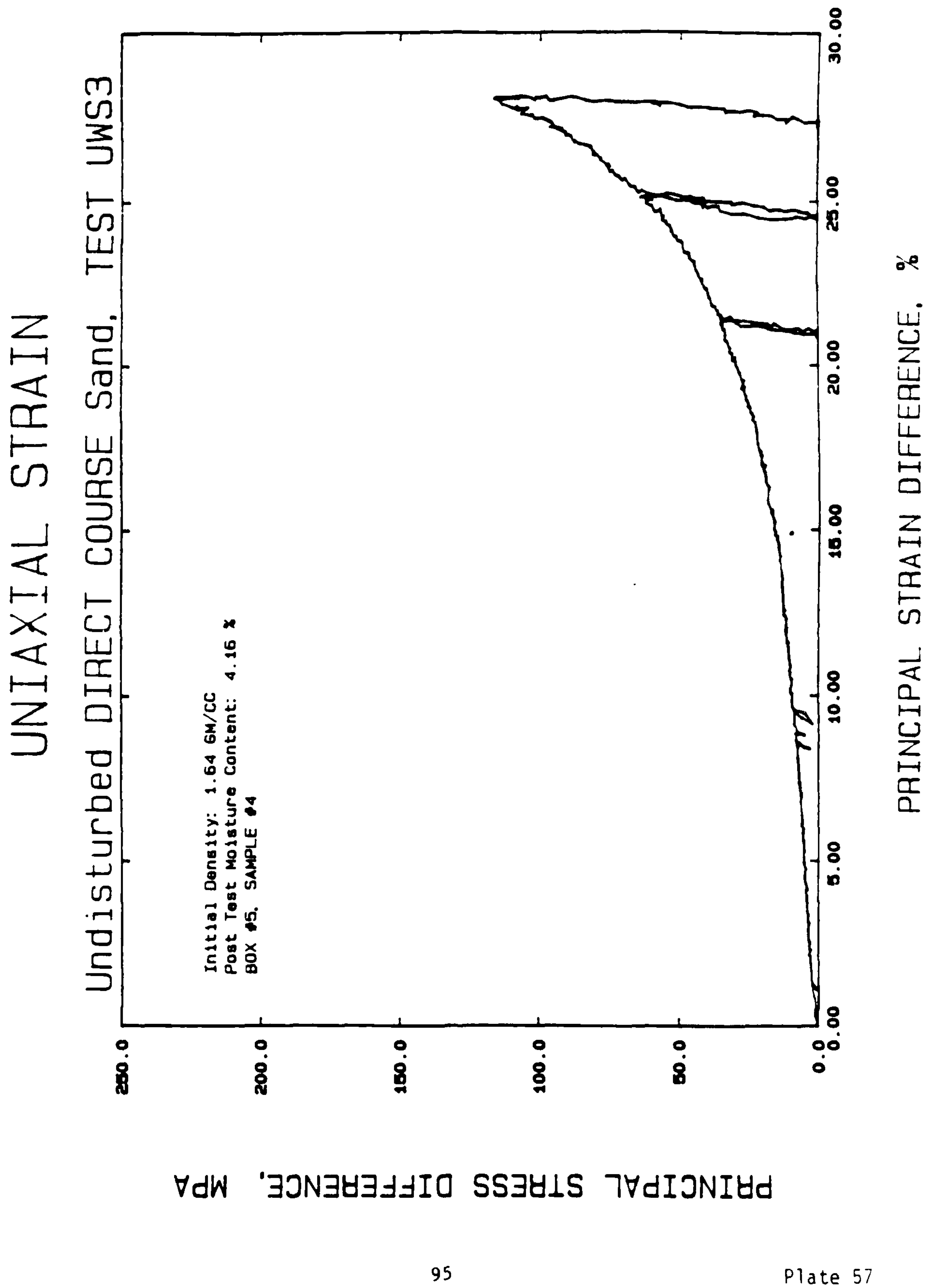
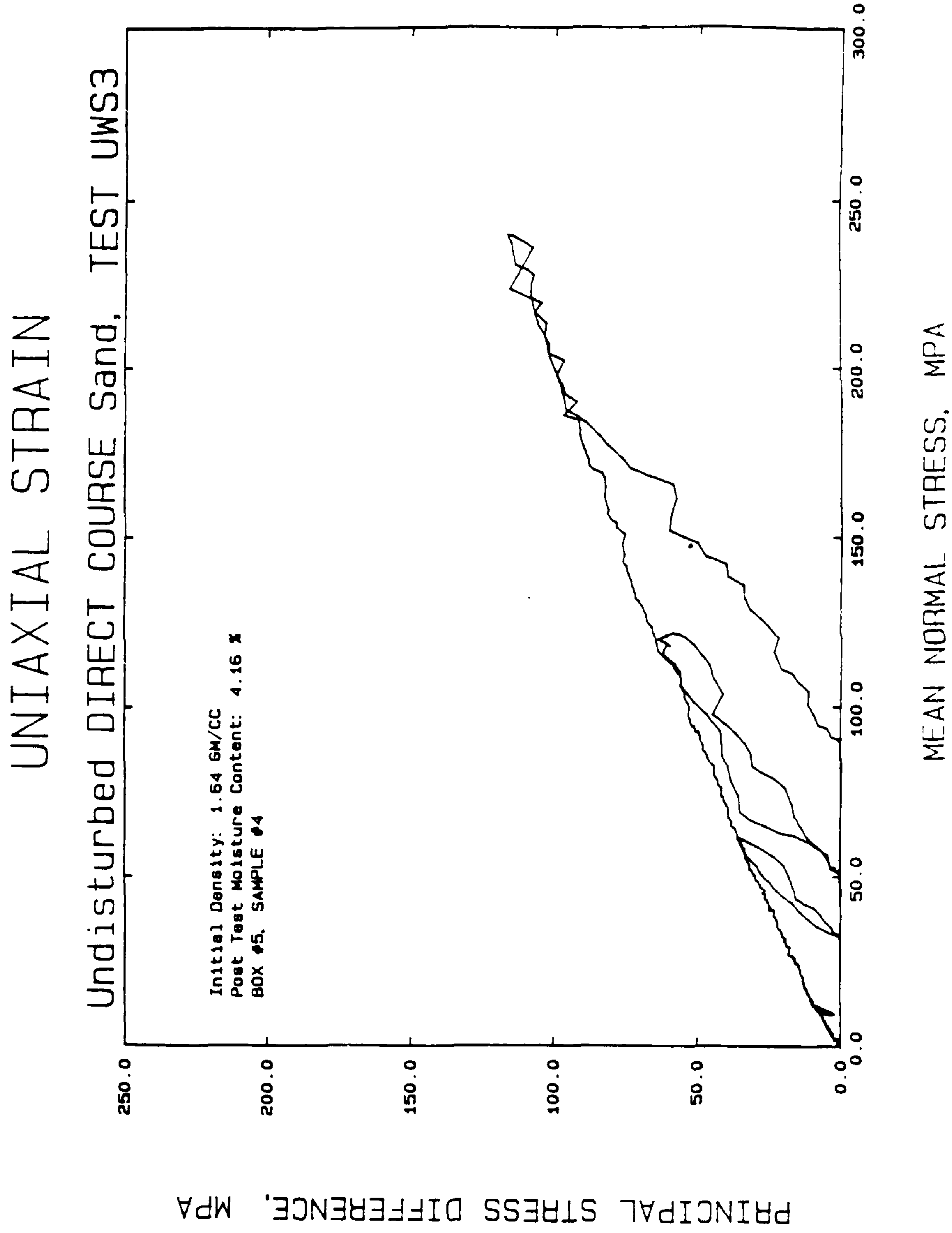
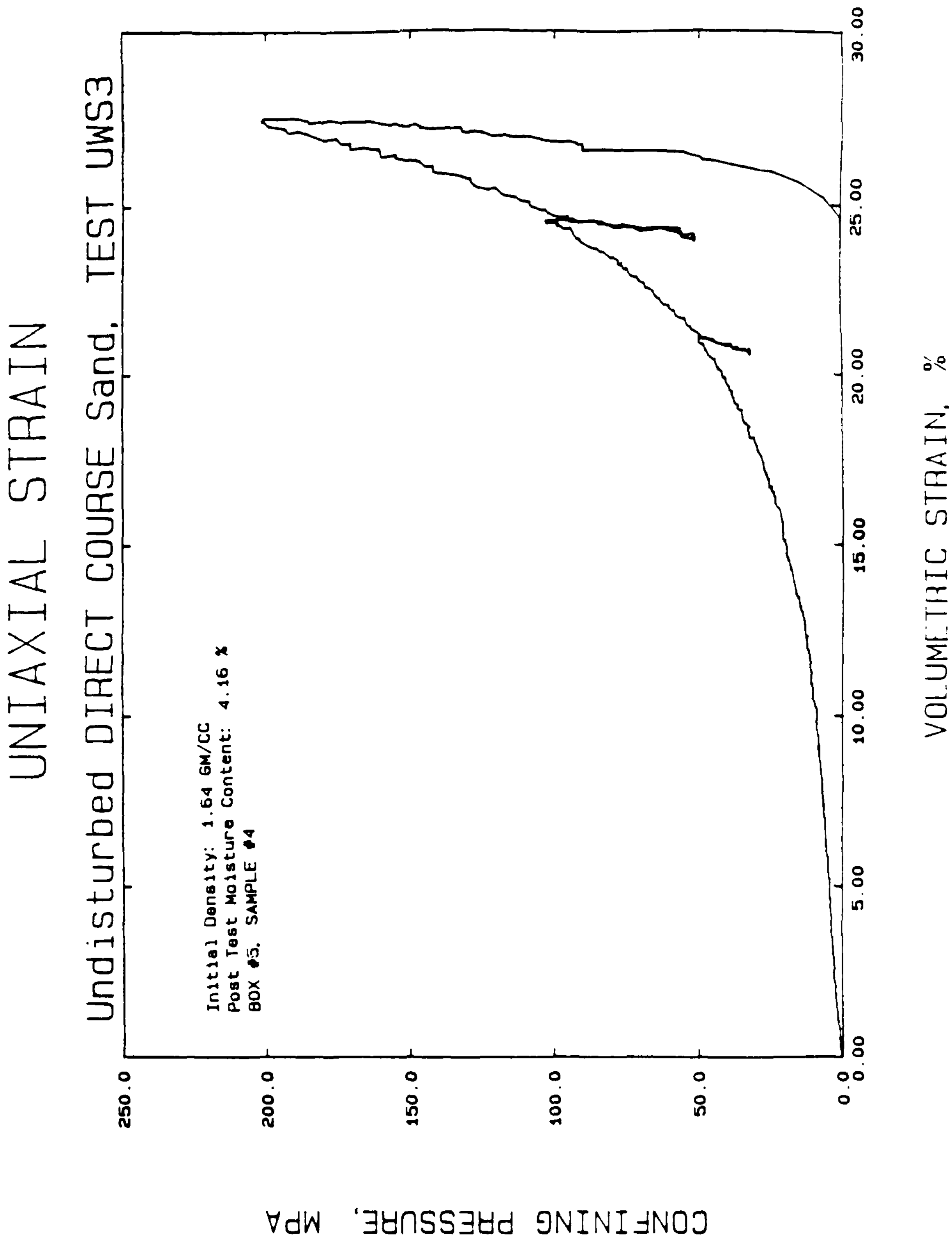

UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS3
Initial Density: 1.64 GM/CC
Post Test Moisture Content: 4.16 %
BOX #5, SAMPLE #4
PRINCIPAL STRESS DIFFERENCE, MPA
250.0
200.0
150.0
100.0
50.0
0.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
PRINCIPAL STRAIN DIFFERENCE, %

Plate 57



UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS3
Initial Density: 1.64 GM/CC
Post Test Moisture Content: 4.16 %
BOX #5, SAMPLE #4
0.0
50.0
100.0
150.0
200.0
250.0
300.0
MEAN NORMAL STRESS, MPA
PRINCIPAL STRESS DIFFERENCE, MPA

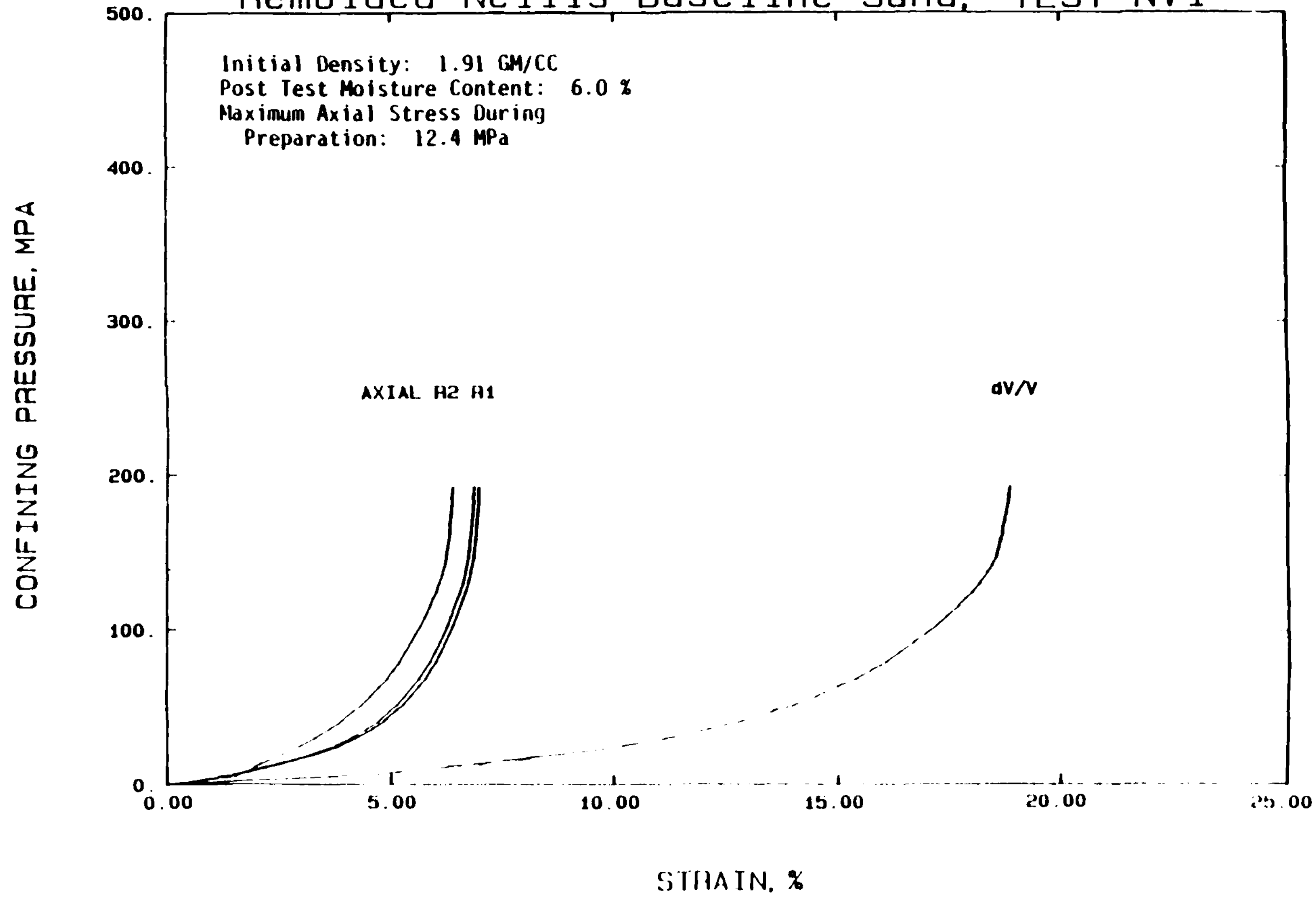
Plate 58

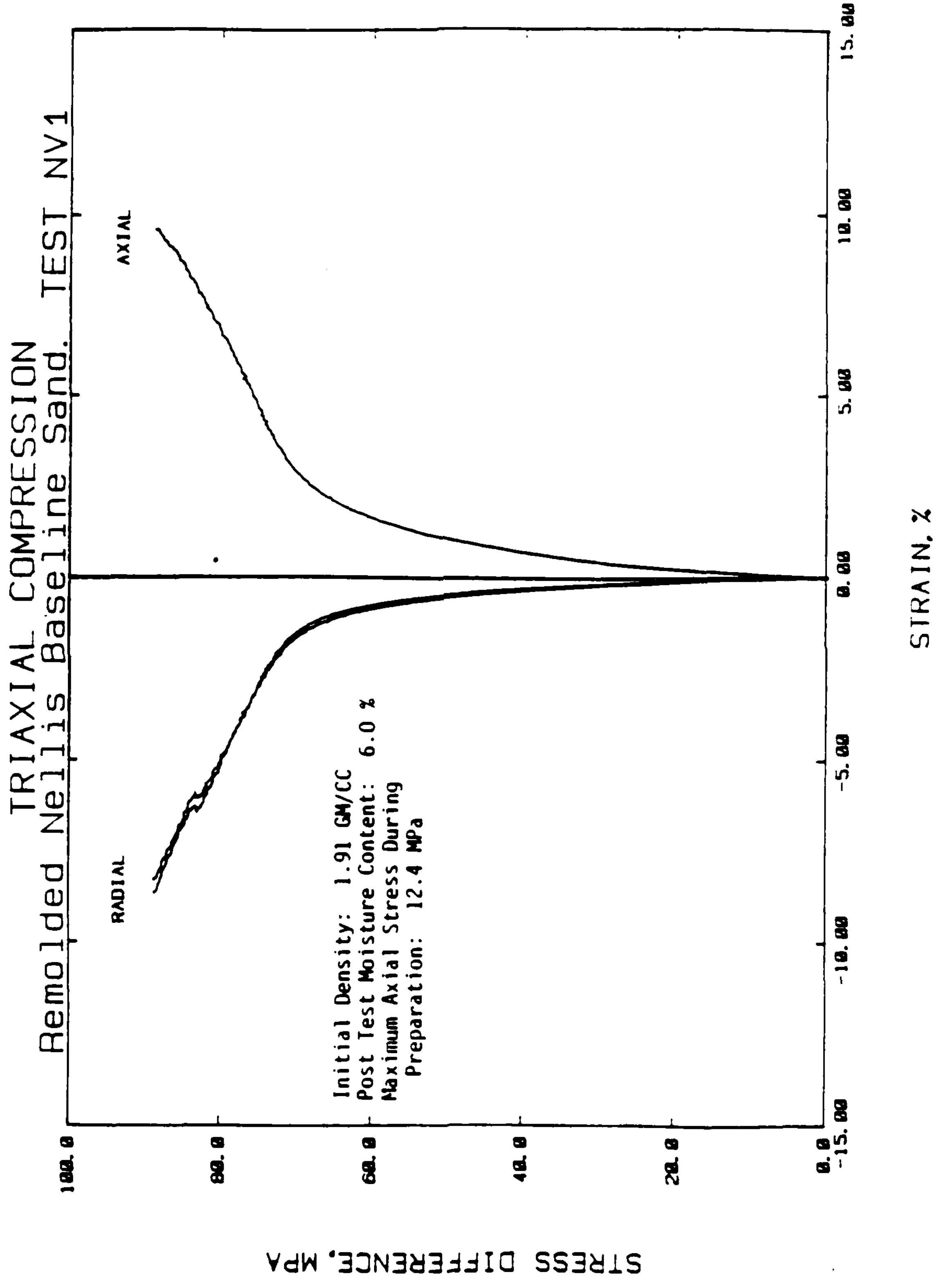


UNIAXIAL STRAIN
Undisturbed DIRECT COURSE Sand, TEST UWS3
Initial Density: 1.64 GM/CC
Post Test Moisture Content: 4.16 %
BOX #5, SAMPLE #4
0.0
50.0
100.0
150.0
200.0
250.0
CONFINING PRESSURE, MPA
0.00
5.00
10.00
15.00
20.00
25.00
30.00
VOLUMETRIC STRAIN, %

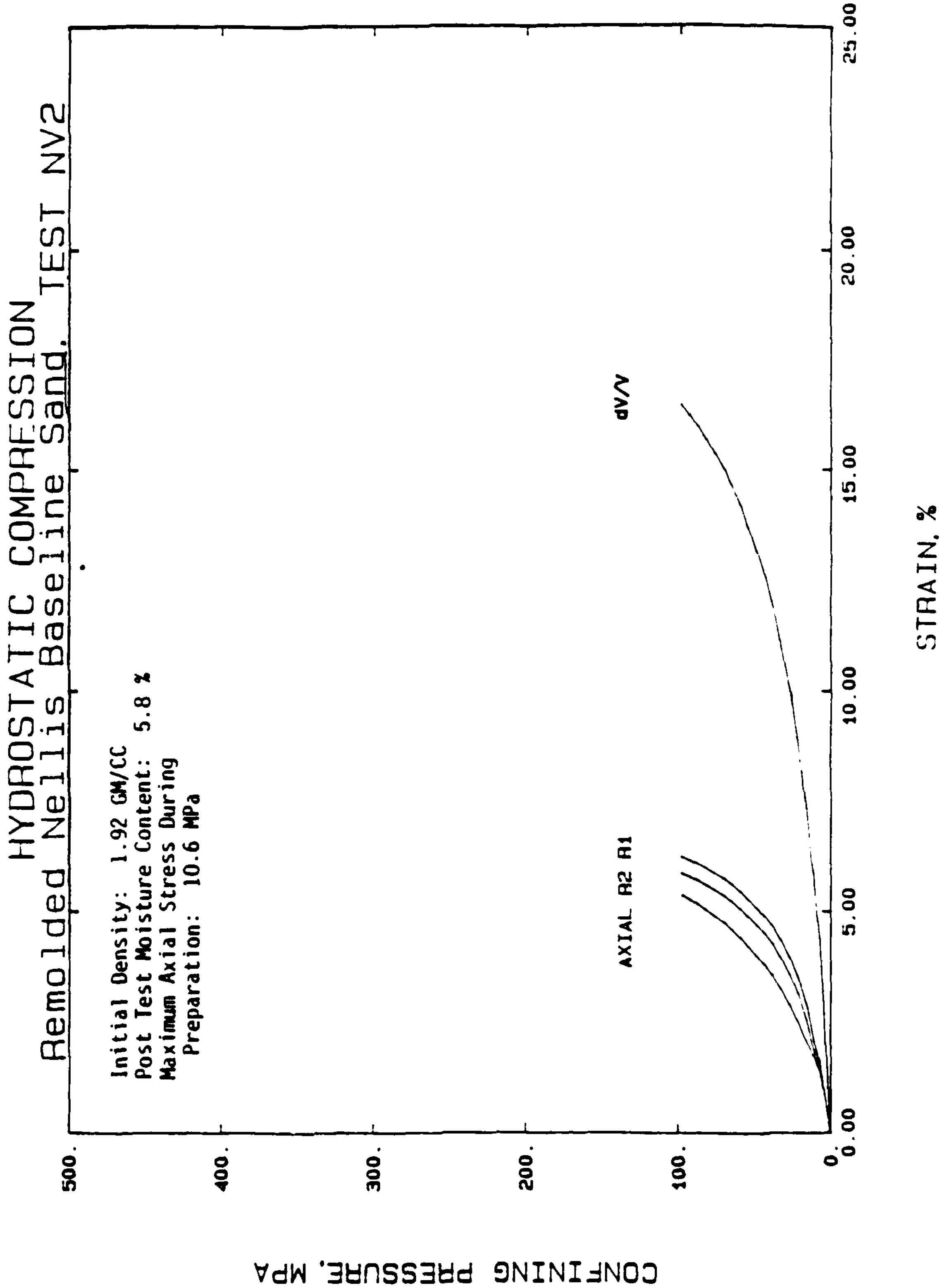
Plate 59

HYDROSTATIC COMPRESSION
Remolded Nellis Baseline Sand, TEST NV1





TRIAXIAL COMPRESSION
Remolded Nellis Baseline Sand. TEST NV1
AXIAL
RADIAL
Initial Density: 1.91 GM/CC
Post Test Moisture Content: 6.0 %
Maximum Axial Stress During
Preparation: 12.4 MPa
STRAIN, %
STRESS DIFFERENCE, MPA
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
0.0
20.0
40.0
60.0
80.0
100.0


HYDROSTATIC COMPRESSION
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.92 GM/CC
Post Test Moisture Content: 5.8 %
Maximum Axial Stress During
Preparation: 10.6 MPa
AXIAL R2 R1
dV/V
CONFINING PRESSURE, MPA
STRAIN, %
0.
100.
200.
300.
400.
500.
0.00
5.00
10.00
15.00
20.00
25.00

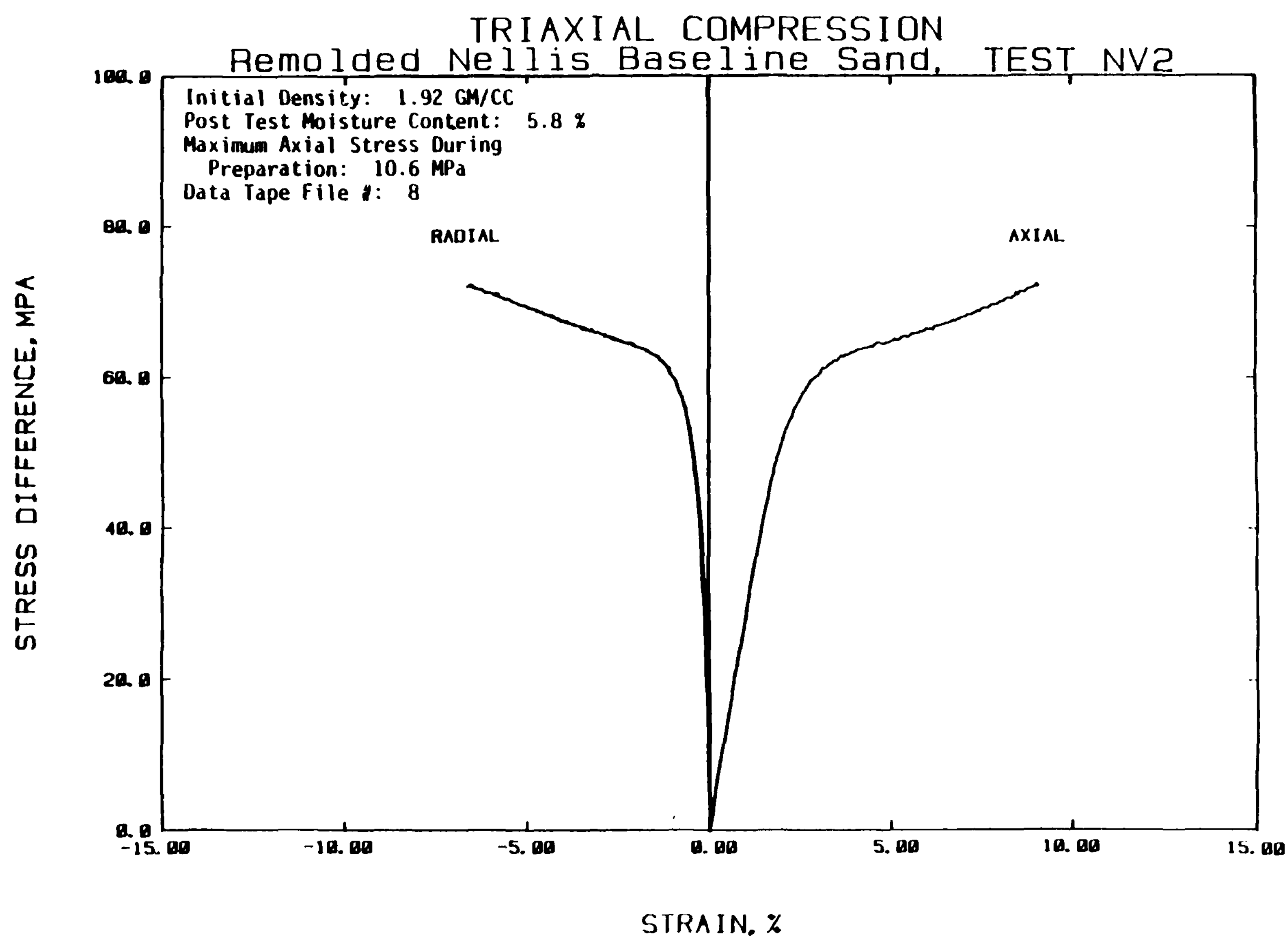

TRIAXIAL COMPRESSION
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.92 GM/CC
Post Test Moisture Content: 5.8 %
Maximum Axial Stress During
Preparation: 10.6 MPa
Data Tape File #: 8
RADIAL
AXIAL
STRESS DIFFERENCE, MPA
STRAIN, %
100.0
80.0
60.0
40.0
20.0
0.0
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00

Plate 63

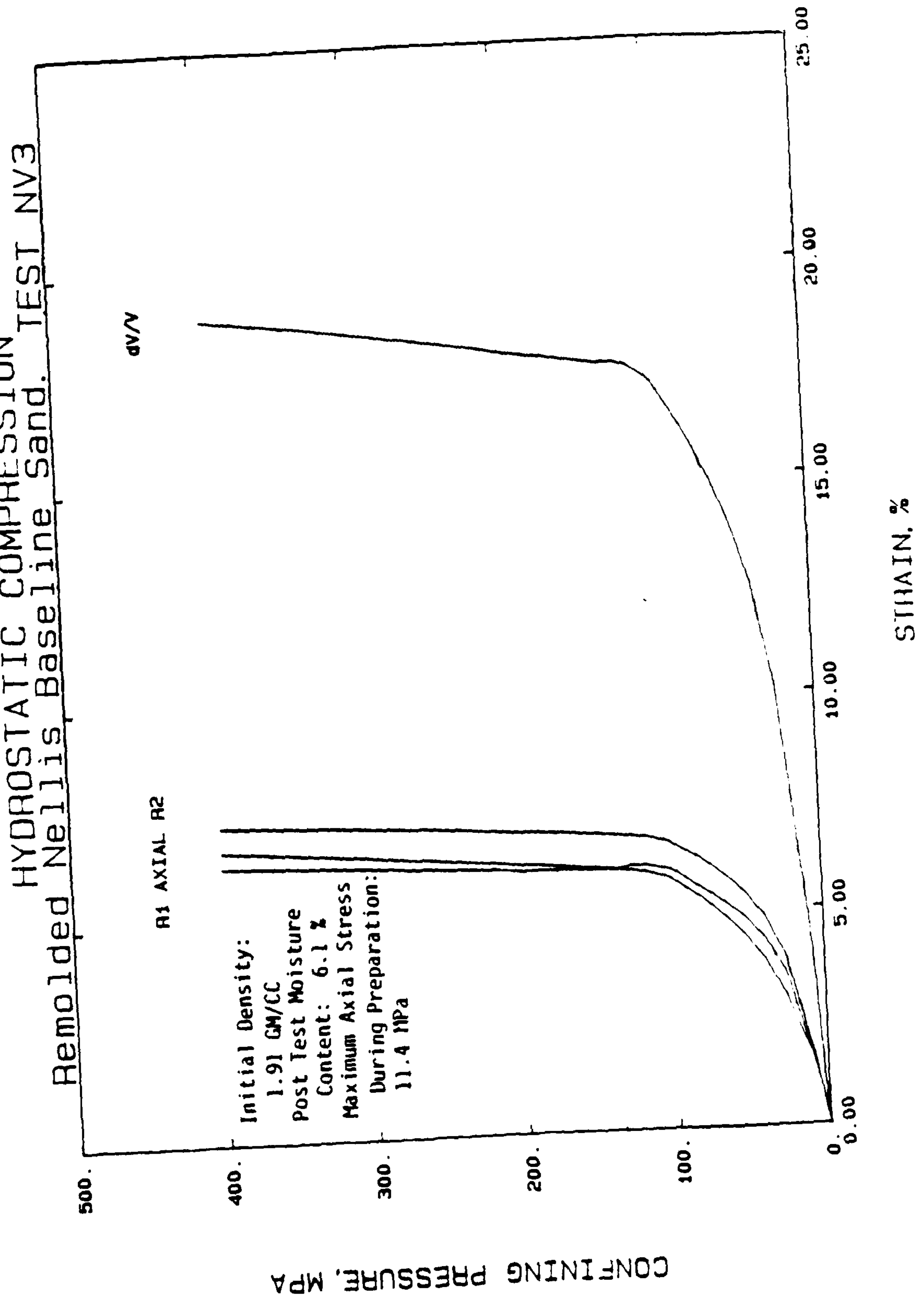

HYDROSTATIC COMPRESSION
Remolded Nellis Baseline Sand. TEST NV3
dV/V
R1 AXIAL R2
Initial Density:
1.91 GM/CC
Post Test Moisture
Content: 6.1 %
Maximum Axial Stress
During Preparation:
11.4 MPa
0.00
5.00
10.00
15.00
20.00
25.00
STRAIN, %
0.
100.
200.
300.
400.
500.
CONFINING PRESSURE, MPA

Plate 61

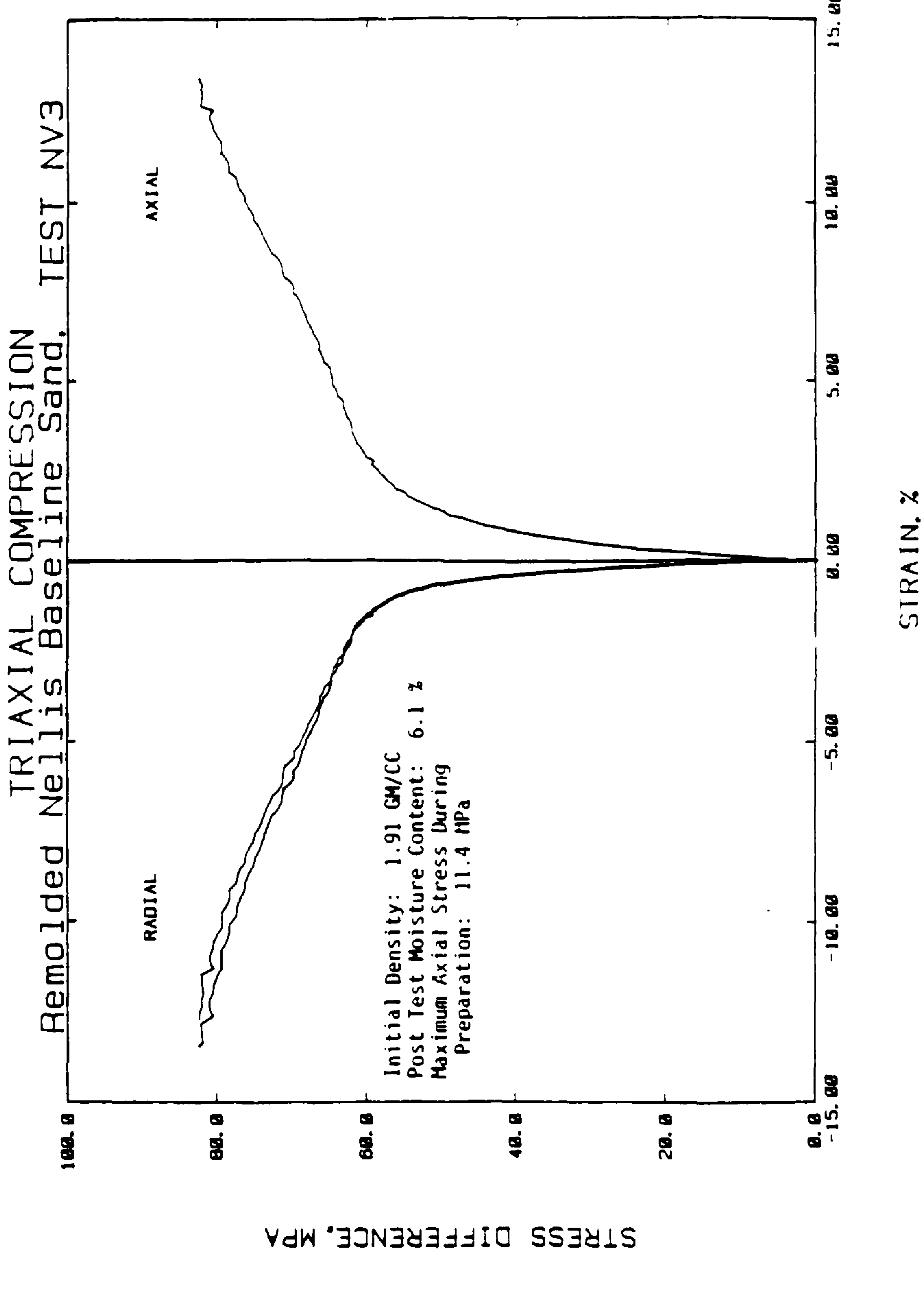
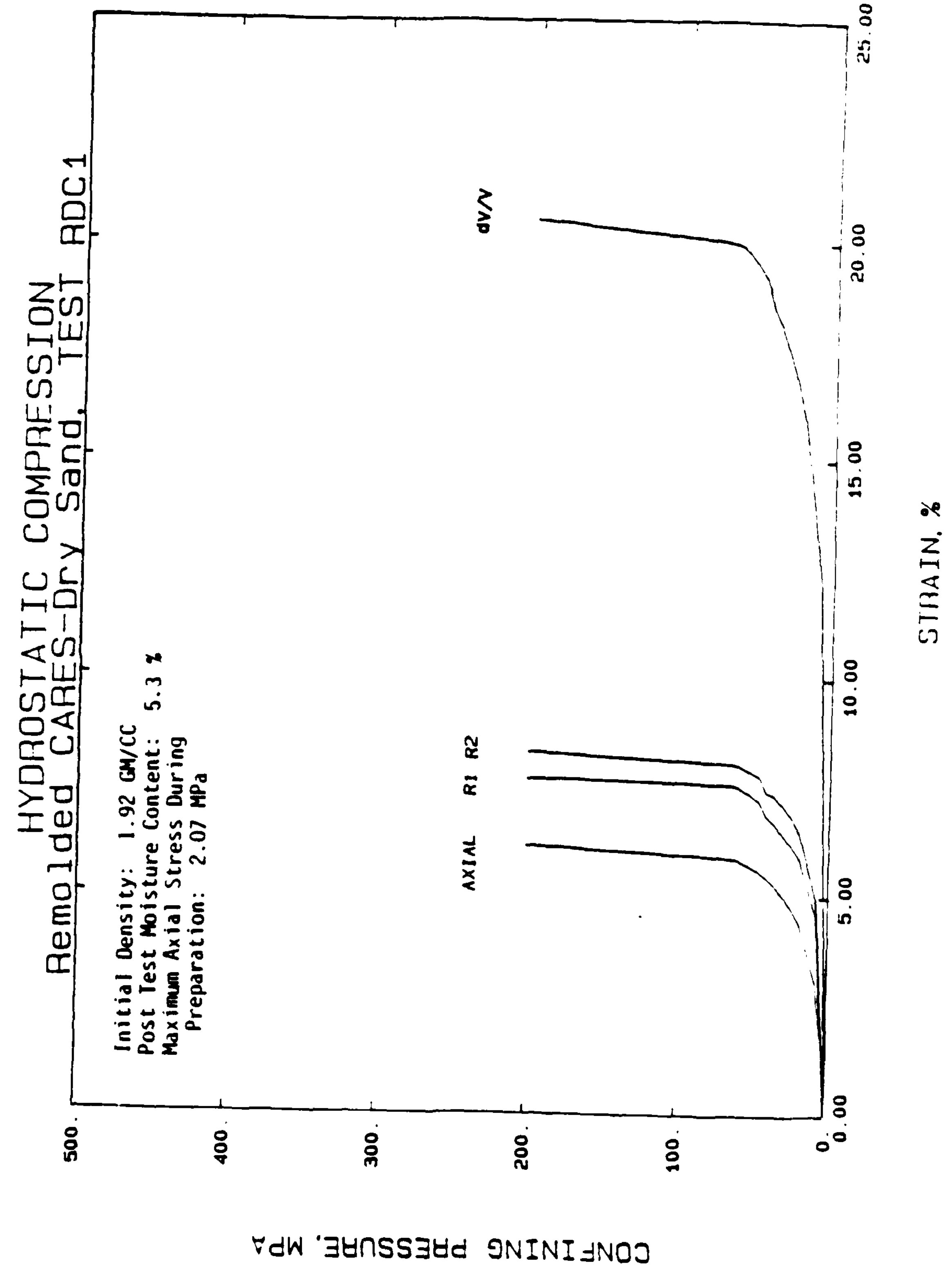
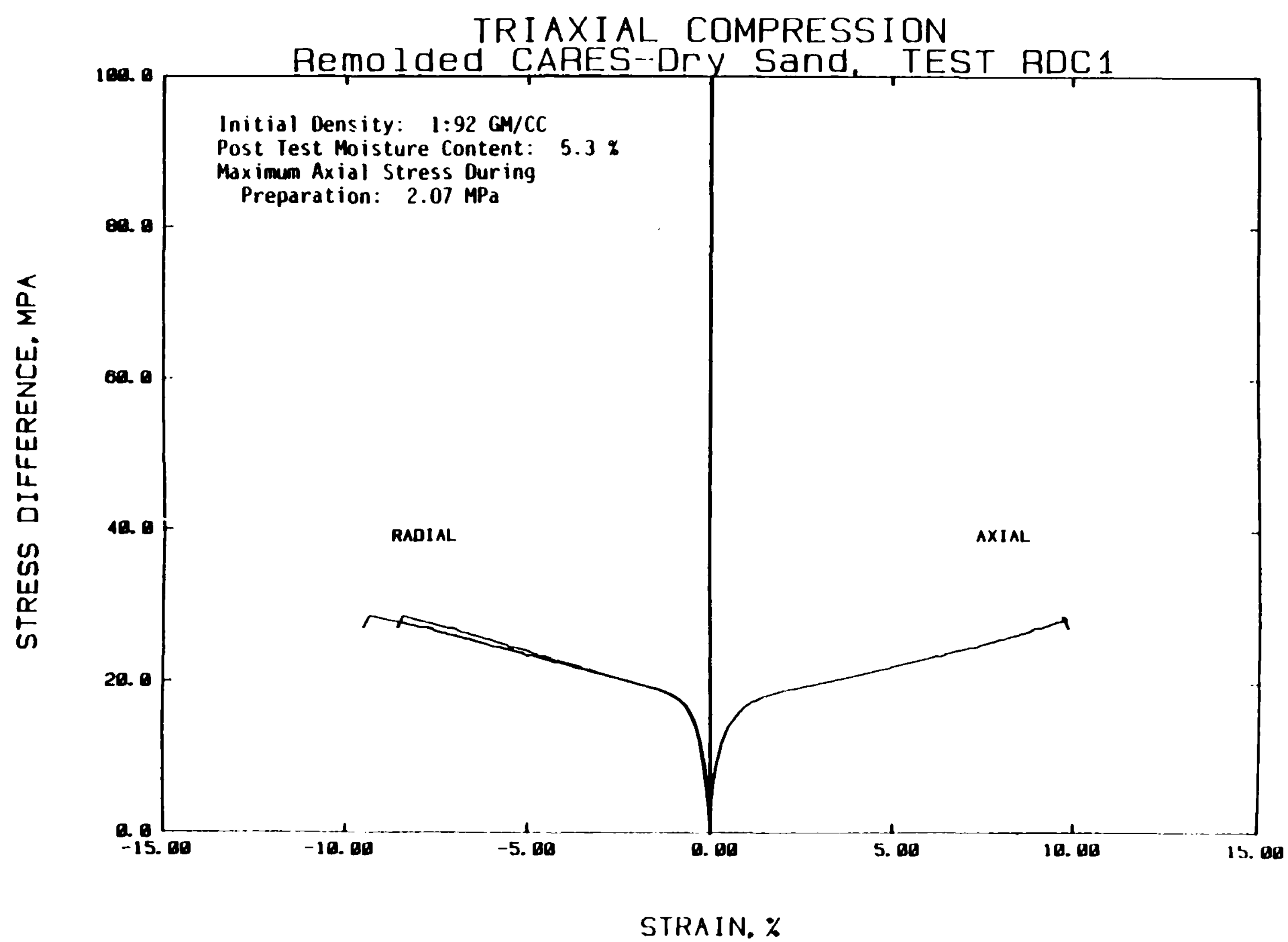
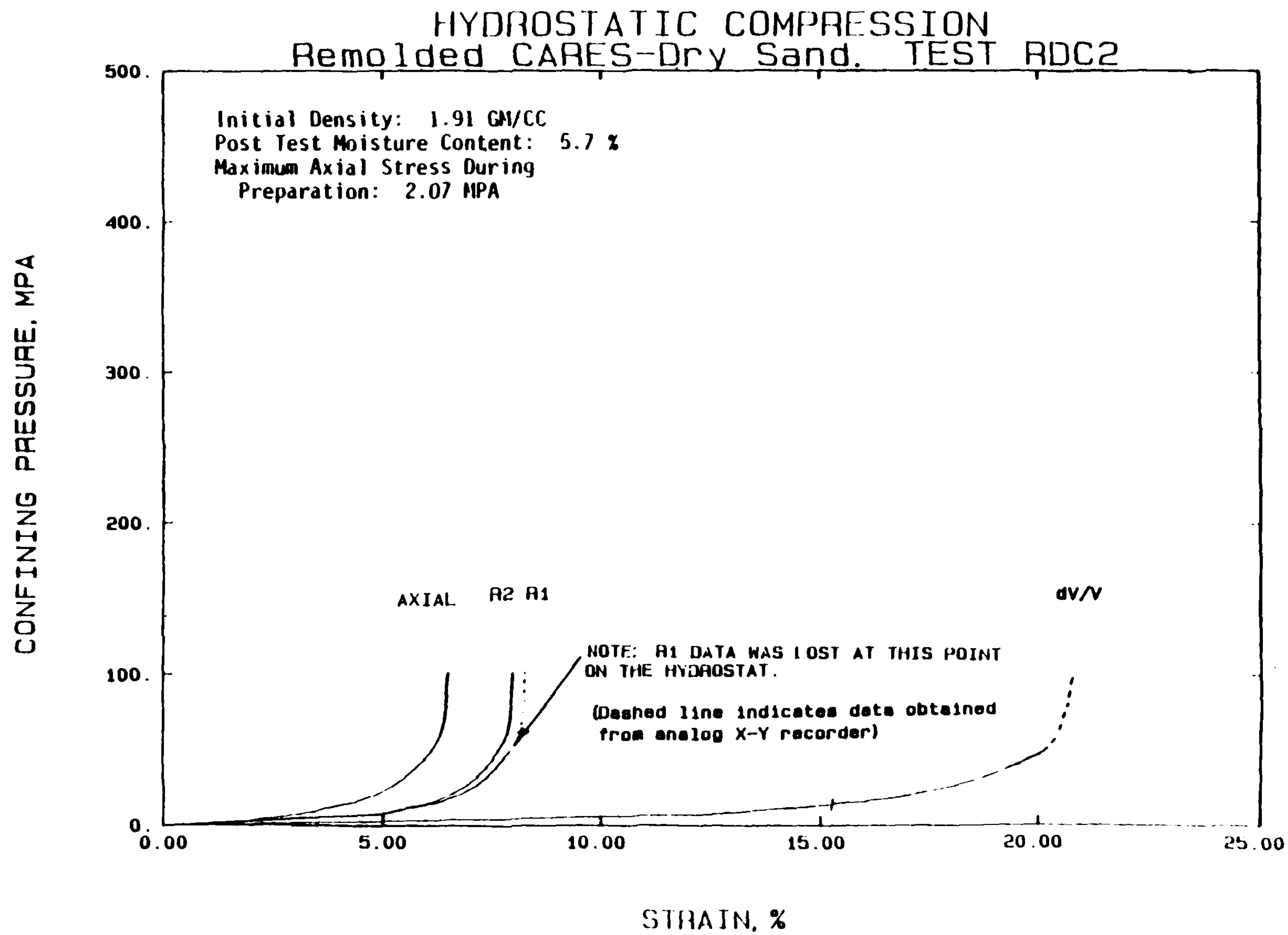

TRIAXIAL COMPRESSION
Remolded Nellis Baseline Sand, TEST NV3
AXIAL
RADIAL
Initial Density: 1.91 GM/CC
Post Test Moisture Content: 6.1 %
Maximum Axial Stress During
Preparation: 11.4 MPa
STRAIN, %
STRESS DIFFERENCE, MPA
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
0.0
20.0
40.0
60.0
80.0
100.0

Plate 65


HYDROSTATIC COMPRESSION
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.92 GM/CC
Post Test Moisture Content: 5.3 %
Maximum Axial Stress During
Preparation: 2.07 MPa
AXIAL
R1 R2
dV/V
0.
100.
200.
300.
400.
500.
0.00
5.00
10.00
15.00
20.00
25.00
STRAIN, %
CONFINING PRESSURE, MPA


TRIAXIAL COMPRESSION
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1:92 GM/CC
Post Test Moisture Content: 5.3 %
Maximum Axial Stress During
Preparation: 2.07 MPa
RADIAL
AXIAL
STRESS DIFFERENCE, MPA
STRAIN, %
100.0
80.0
60.0
40.0
20.0
0.0
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00



HYDROSTATIC COMPRESSION
Remolded CARES-Dry Sand. TEST RDC2
Initial Density: 1.91 GM/CC
Post Test Moisture Content: 5.7 %
Maximum Axial Stress During
Preparation: 2.07 MPA
AXIAL
R2 R1
dV/V
NOTE: R1 DATA WAS LOST AT THIS POINT ON THE HYDROSTAT.
(Dashed line indicates data obtained from analog X-Y recorder)
CONFINING PRESSURE, MPA
STRAIN, %
0.
100.
200.
300.
400.
500.
0.00
5.00
10.00
15.00
20.00
25.00

Plate 68

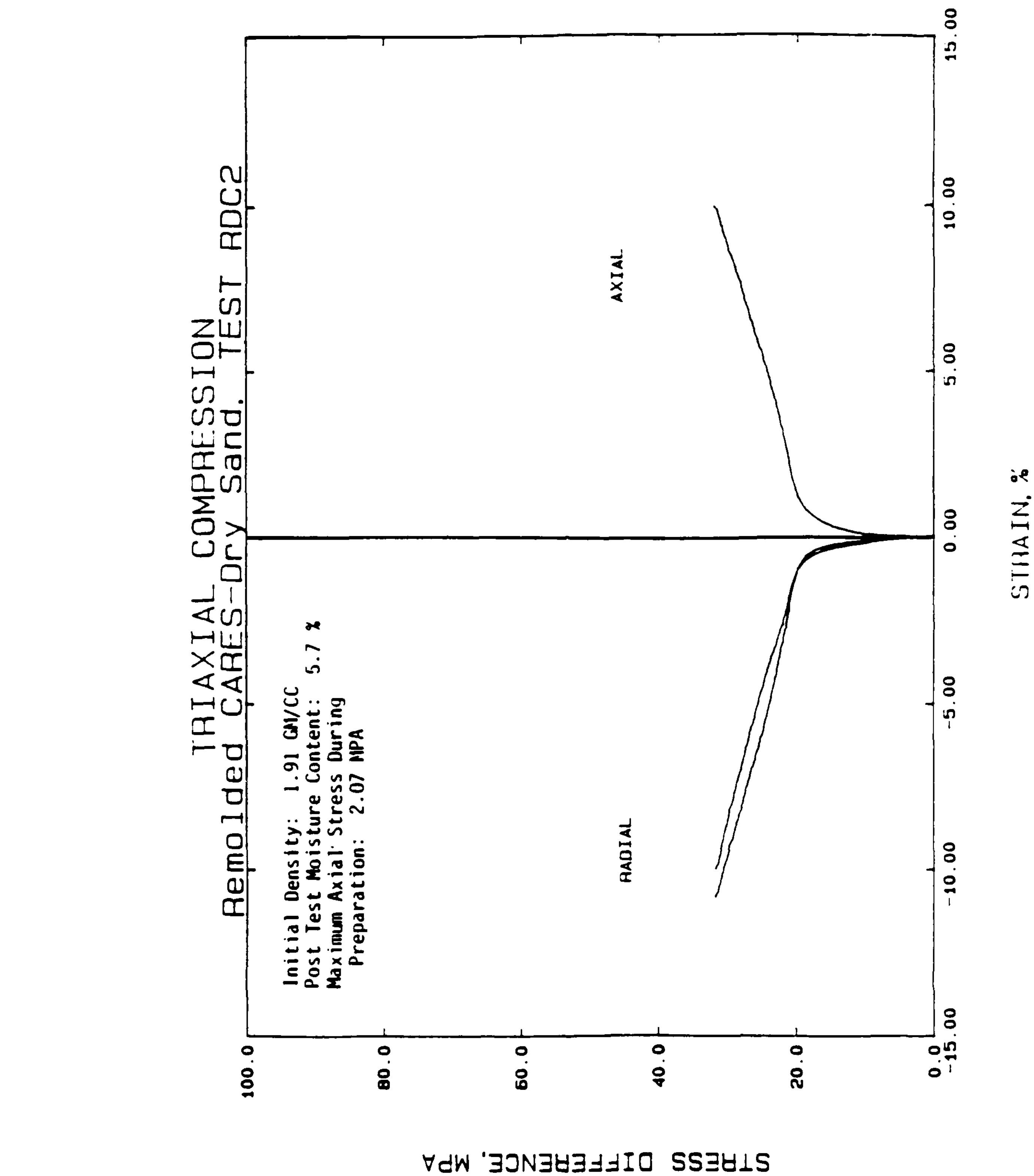
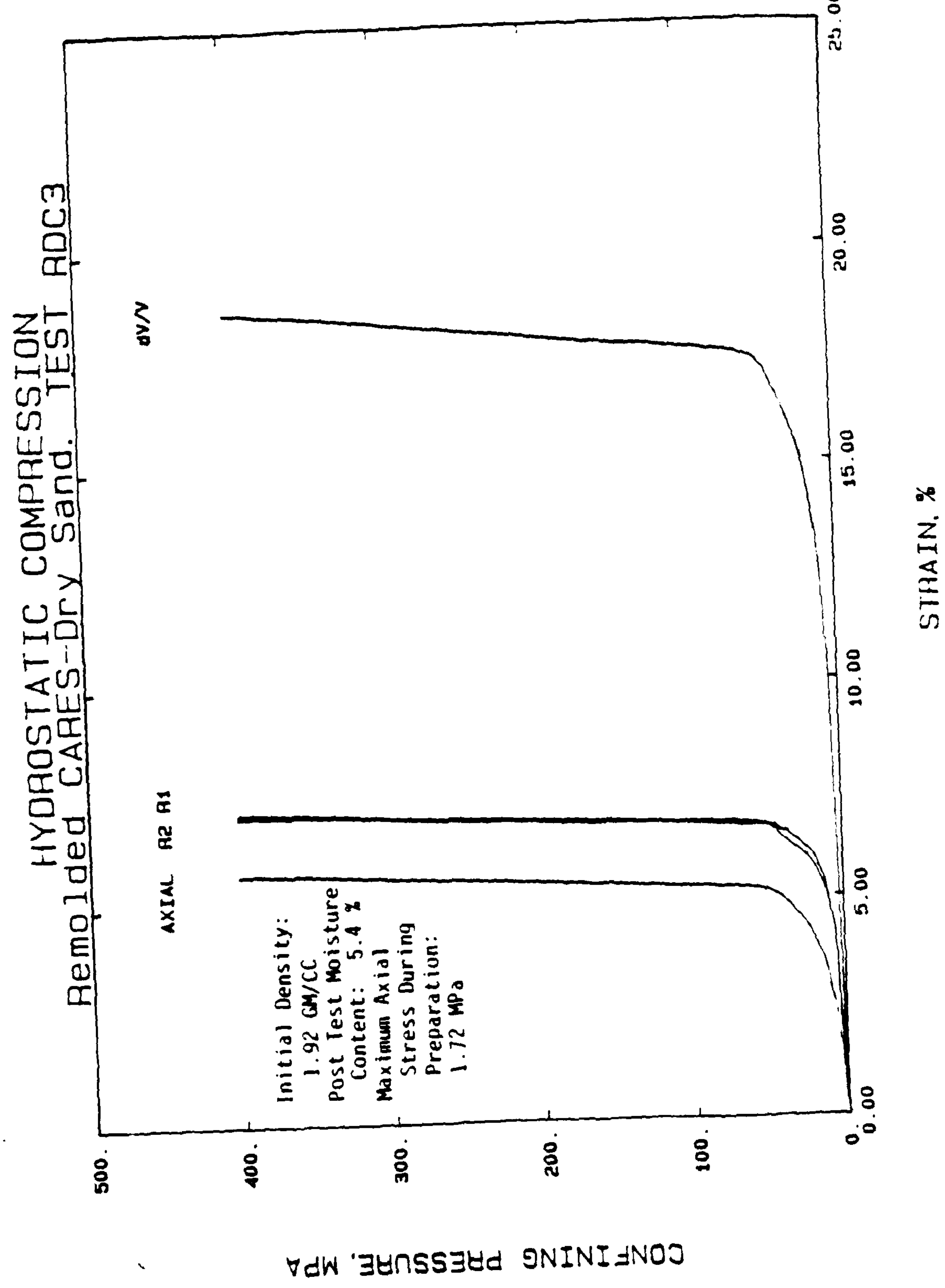
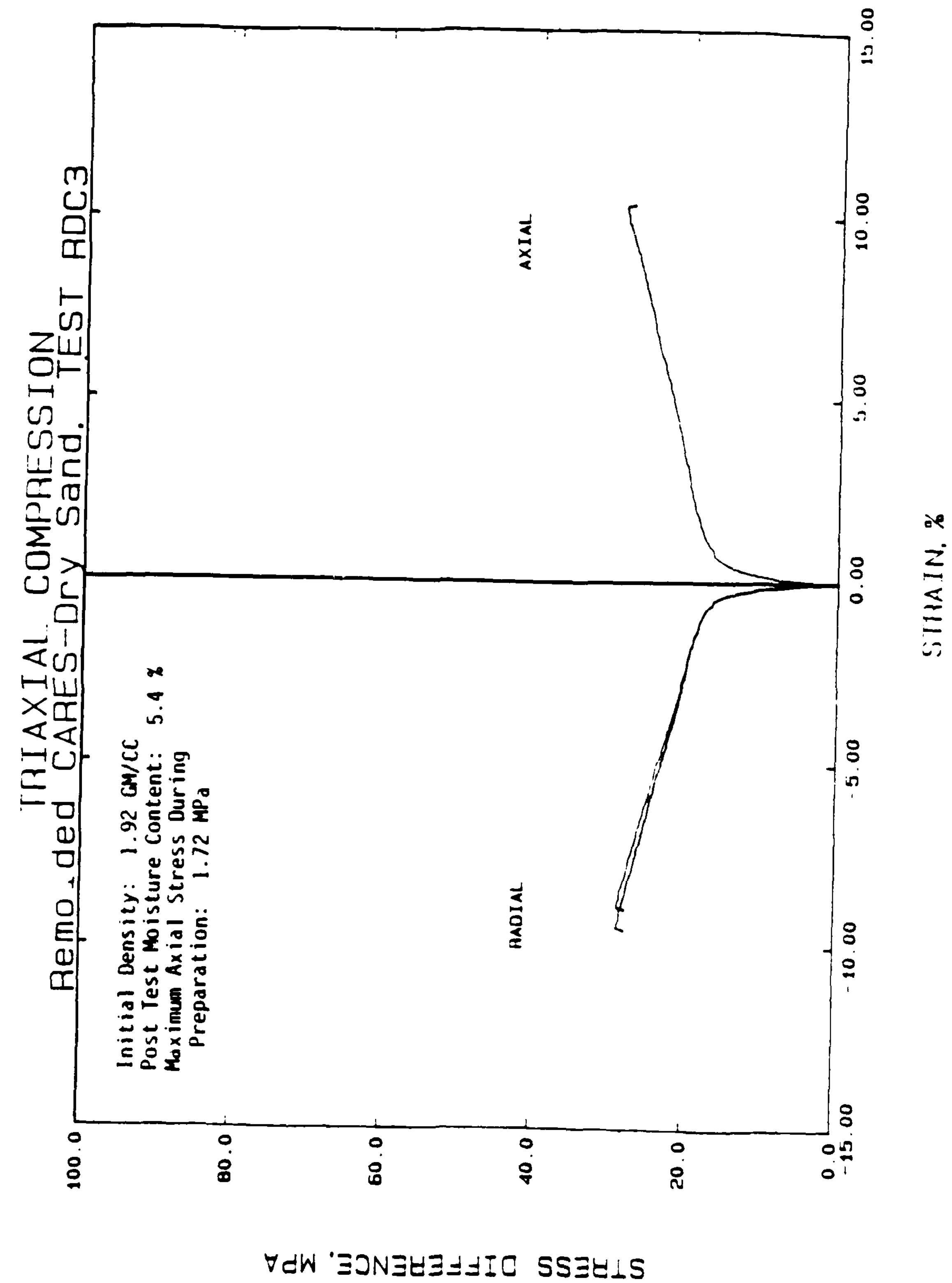

TRIAXIAL COMPRESSION
Remolded CARES-Dry Sand. TEST RDC2
Initial Density: 1.91 GM/CC
Post Test Moisture Content: 5.7 %
Maximum Axial Stress During
Preparation: 2.07 MPA
AXIAL
RADIAL
STRESS DIFFERENCE, MPA
STRAIN, %
0.0
20.0
40.0
60.0
80.0
100.0
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00

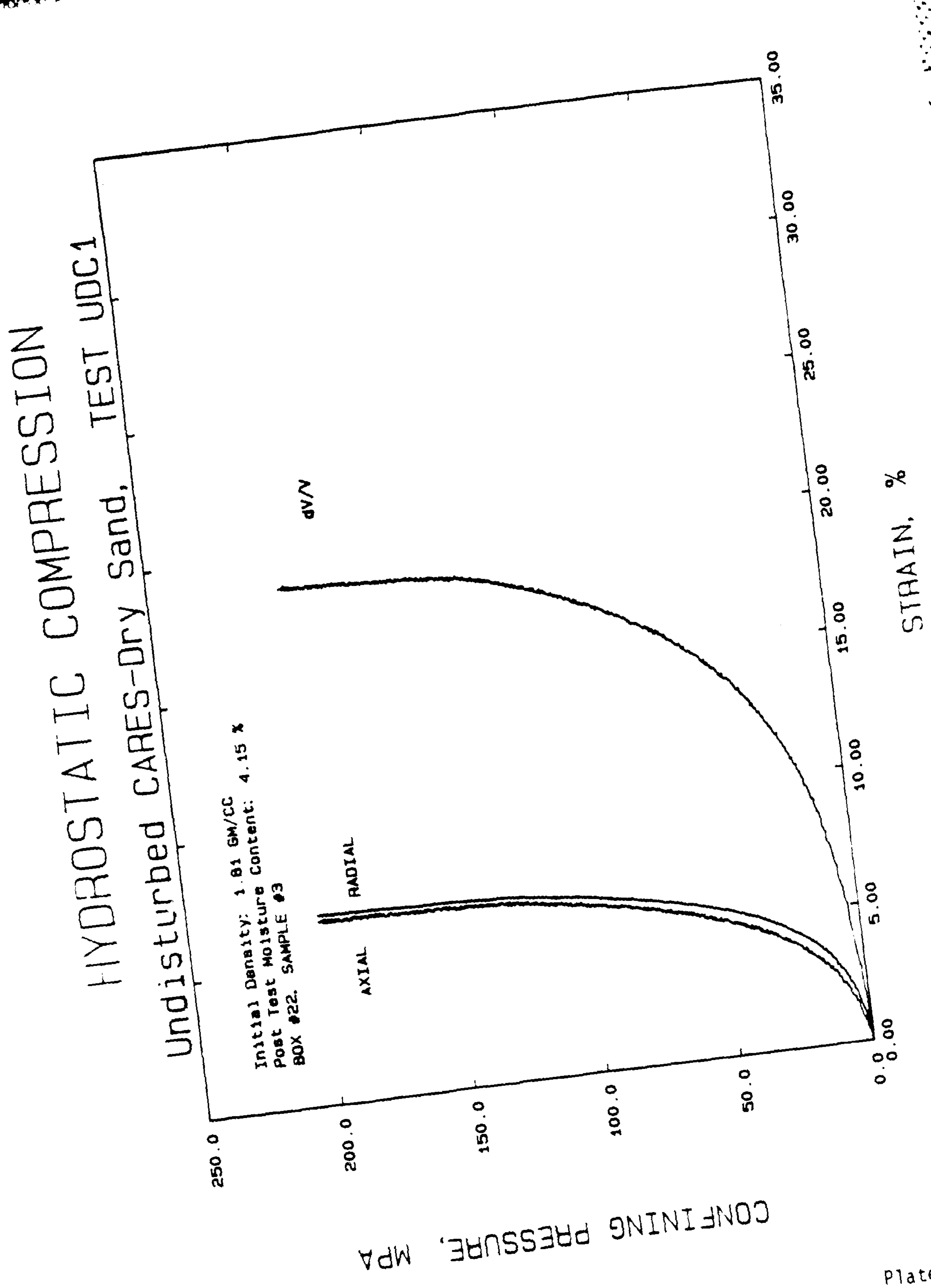
Plate 69


HYDROSTATIC COMPRESSION
Remolded CARES-Dry Sand. TEST RDC3
dV/V
AXIAL R2 R1
Initial Density:
1.92 GM/CC
Post Test Moisture
Content: 5.4 %
Maximum Axial
Stress During
Preparation:
1.72 MPa
0.00
5.00
10.00
15.00
20.00
25.00
STRAIN, %
0.
100.
200.
300.
400.
500.
CONFINING PRESSURE, MPA



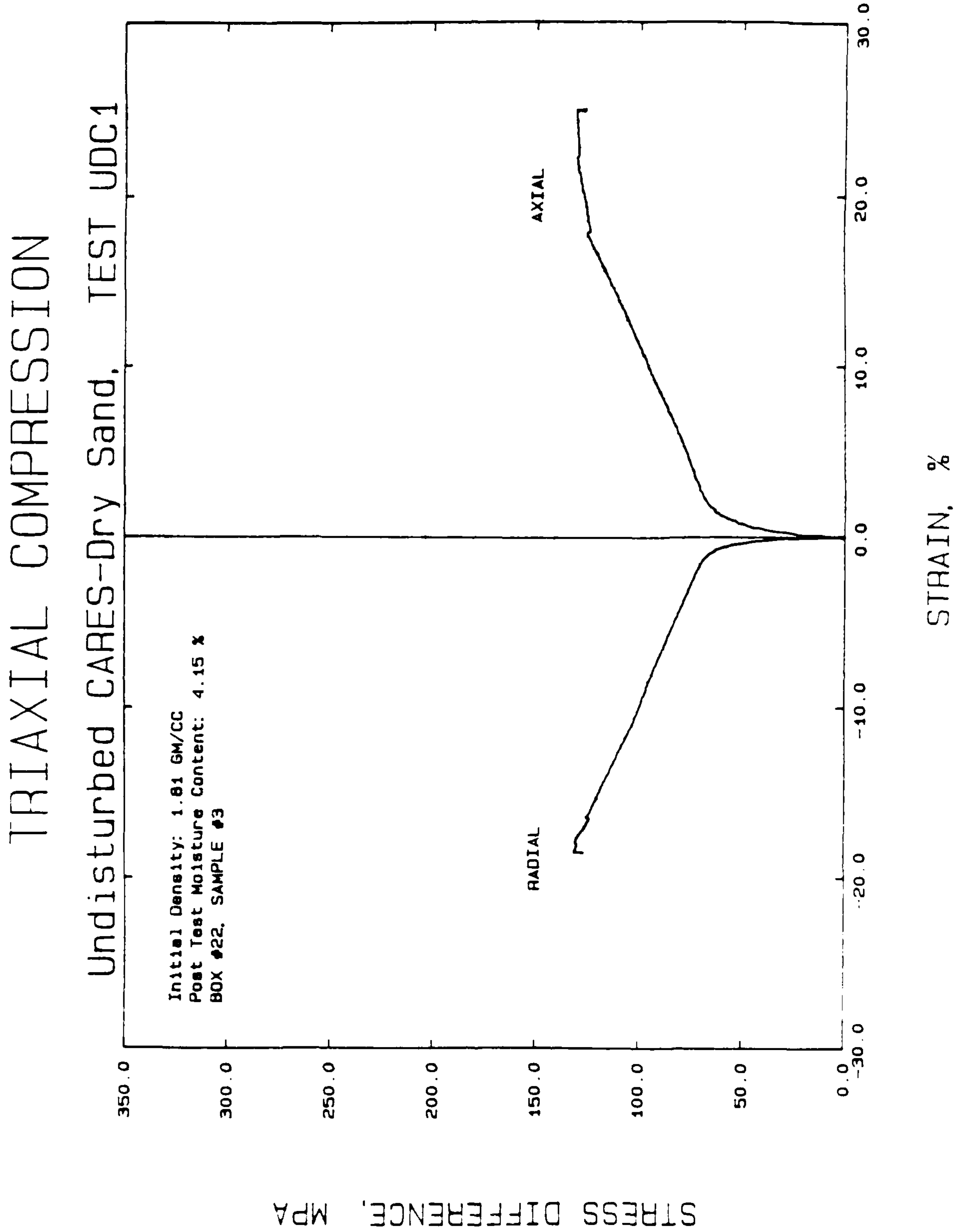
TRIAXIAL COMPRESSION
Remo.ded CARES-Dry Sand, TEST RDC3
Initial Density: 1.92 GM/CC
Post Test Moisture Content: 5.4 %
Maximum Axial Stress During
Preparation: 1.72 MPa
AXIAL
RADIAL
STRESS DIFFERENCE, MPA
STRAIN, %
100.0
80.0
60.0
40.0
20.0
0.0
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00

Plate 71



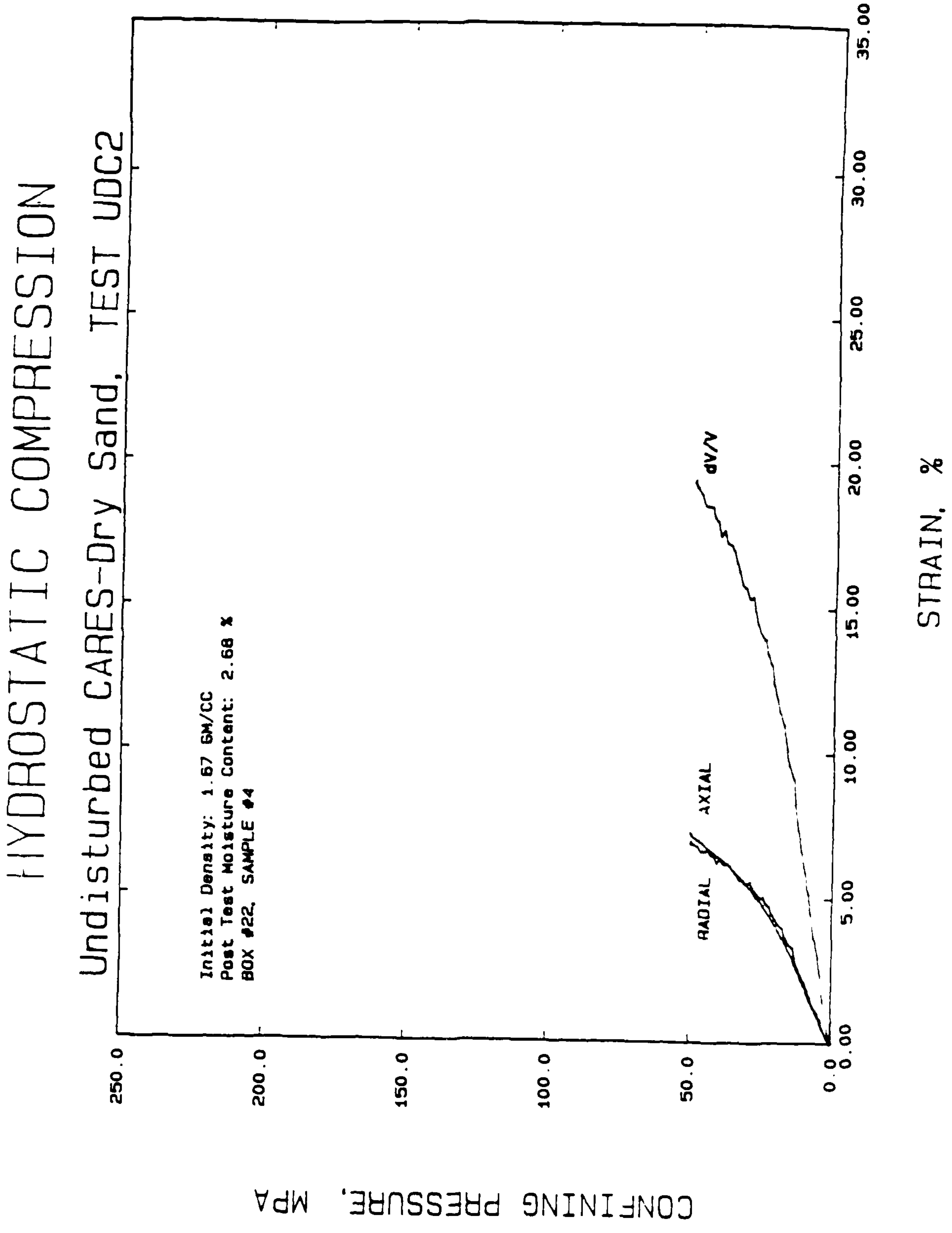
HYDROSTATIC COMPRESSION
Undisturbed CARES-Dry Sand, TEST UDC1
Initial Density: 1.81 GM/CC
Post Test Moisture Content: 4.15 %
BOX #22, SAMPLE #3
AXIAL
RADIAL
dV/V
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
CONFINING PRESSURE, MPA

Plate 72

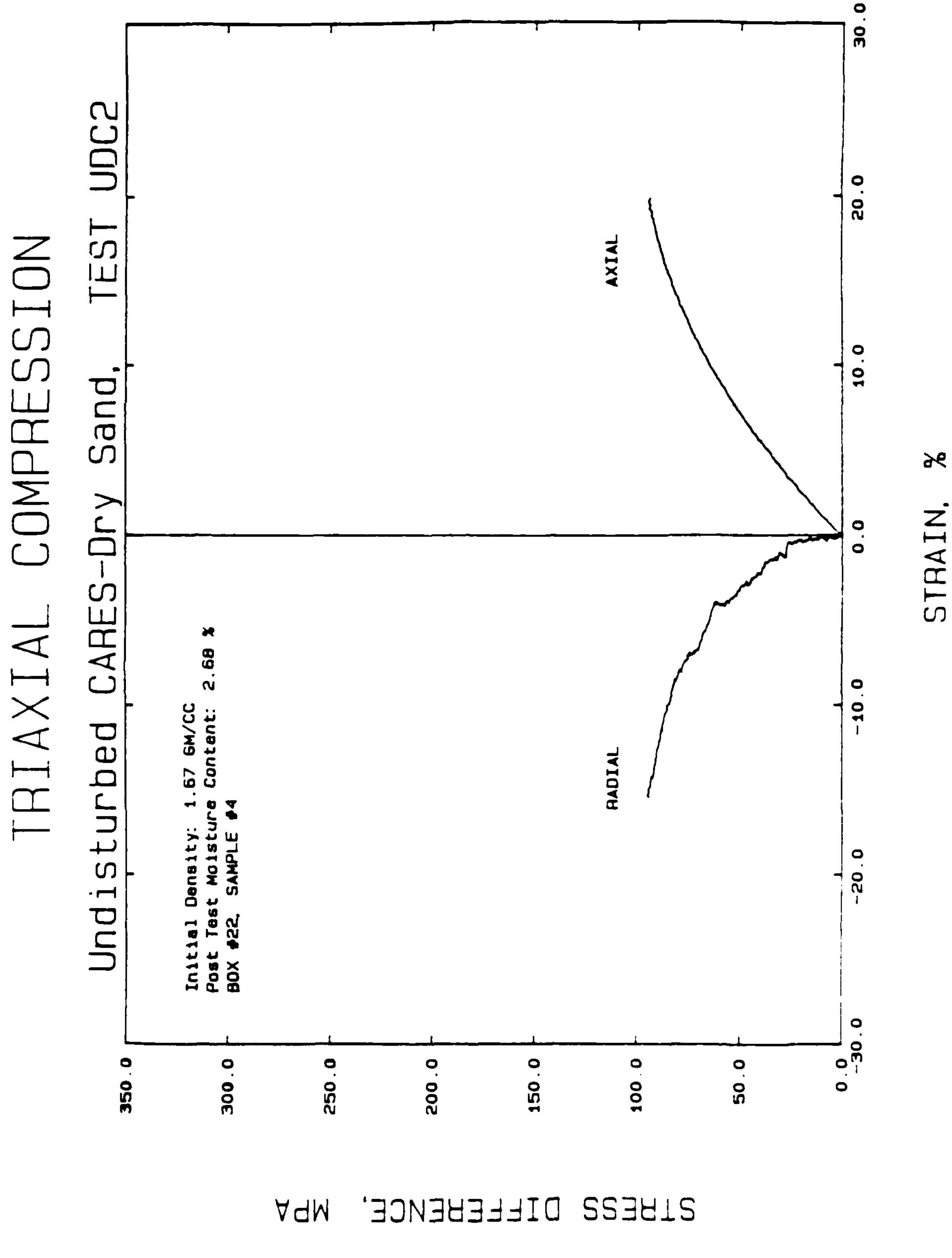


TRIAXIAL COMPRESSION
Undisturbed CARES-Dry Sand, TEST UDC1
Initial Density: 1.81 GM/CC
Post Test Moisture Content: 4.15 %
BOX #22, SAMPLE #3
AXIAL
RADIAL
STRESS DIFFERENCE, MPA
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
STRAIN, %
-30.0
-20.0
-10.0
0.0
10.0
20.0
30.0

Plate 73



HYDROSTATIC COMPRESSION
Undisturbed CARES-Dry Sand, TEST UDC2
Initial Density: 1.67 GM/CC
Post Test Moisture Content: 2.68 %
BOX #22, SAMPLE #4
RADIAL
AXIAL
dV/V
250.0
200.0
150.0
100.0
50.0
0.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
STRAIN, %
CONFINING PRESSURE, MPA



TRIAXIAL COMPRESSION
Undisturbed CARES-Dry Sand, TEST UDC2
Initial Density: 1.67 GM/CC
Post Test Moisture Content: 2.68 %
BOX #22, SAMPLE #4
AXIAL
RADIAL
STRESS DIFFERENCE, MPA
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-30.0
-20.0
-10.0
0.0
10.0
20.0
30.0
STRAIN, %

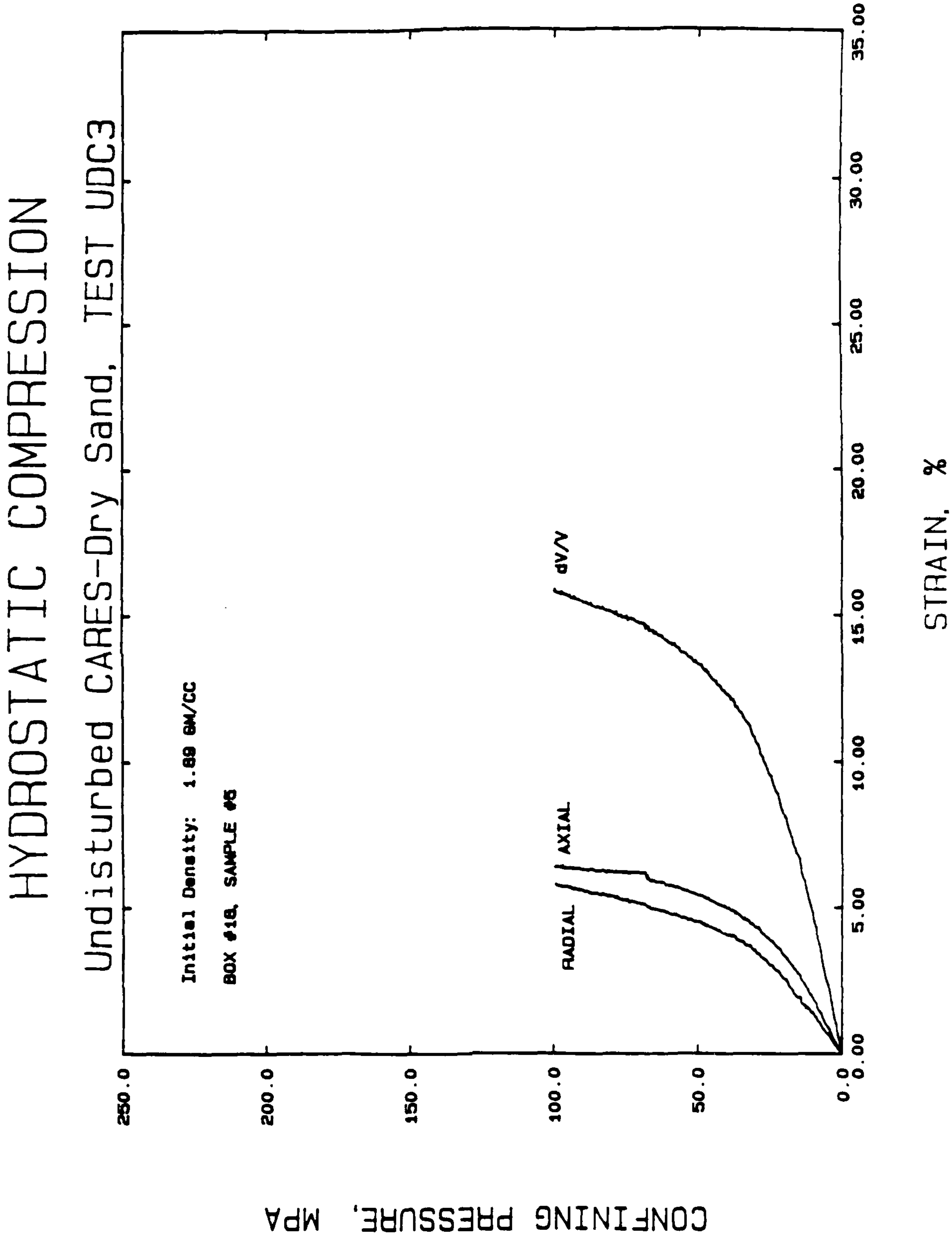

HYDROSTATIC COMPRESSION
Undisturbed CARES-Dry Sand, TEST UDC3
Initial Density: 1.69 GM/CC
BOX #18, SAMPLE #5
RADIAL
AXIAL
dV/V
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
CONFINING PRESSURE, MPA

Plate 76

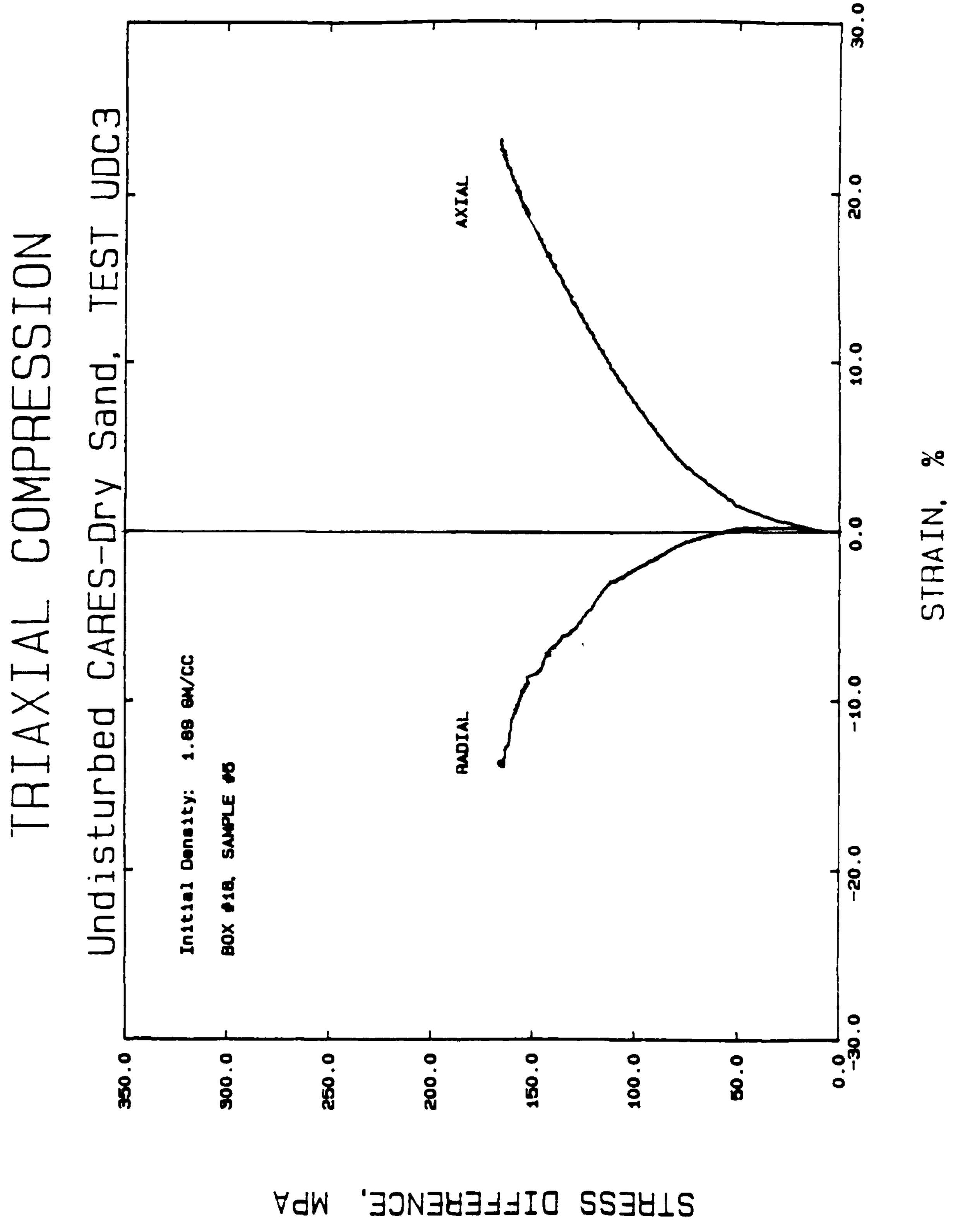
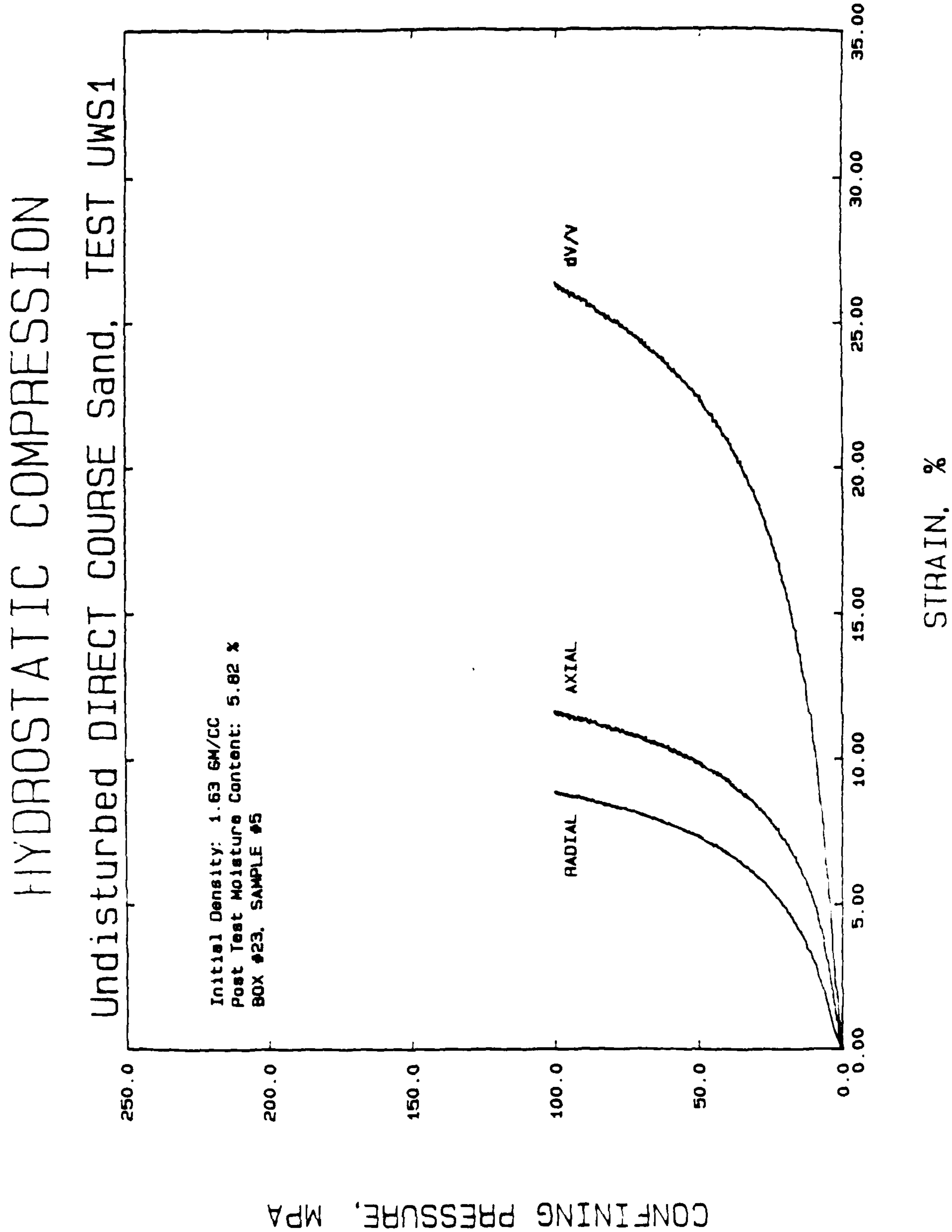
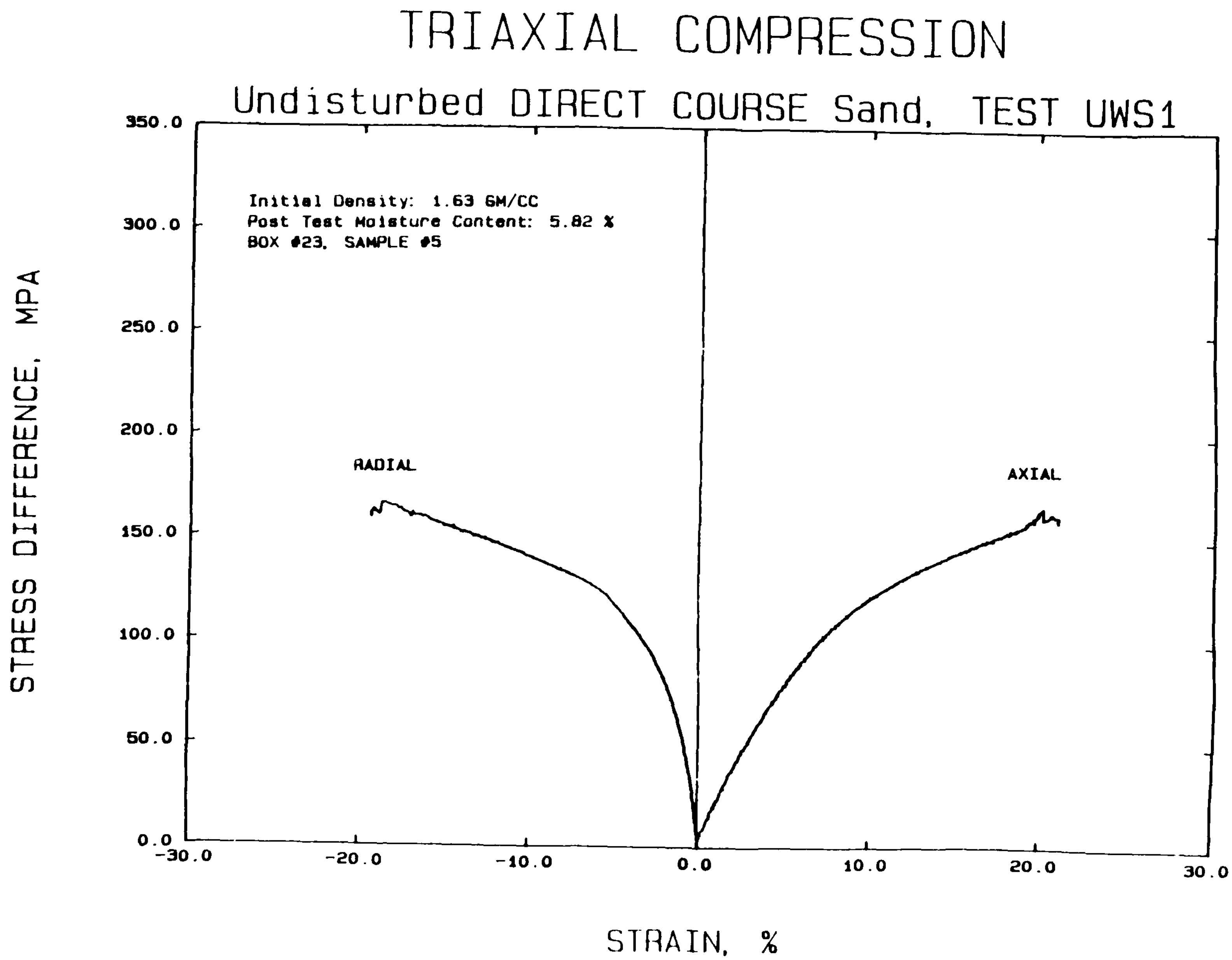

TRIAXIAL COMPRESSION
Undisturbed CARES-Dry Sand, TEST UDC3
Initial Density: 1.89 GM/CC
BOX #18, SAMPLE #5
AXIAL
RADIAL
STRESS DIFFERENCE, MPA
STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
-30.0
-20.0
-10.0
0.0
10.0
20.0
30.0

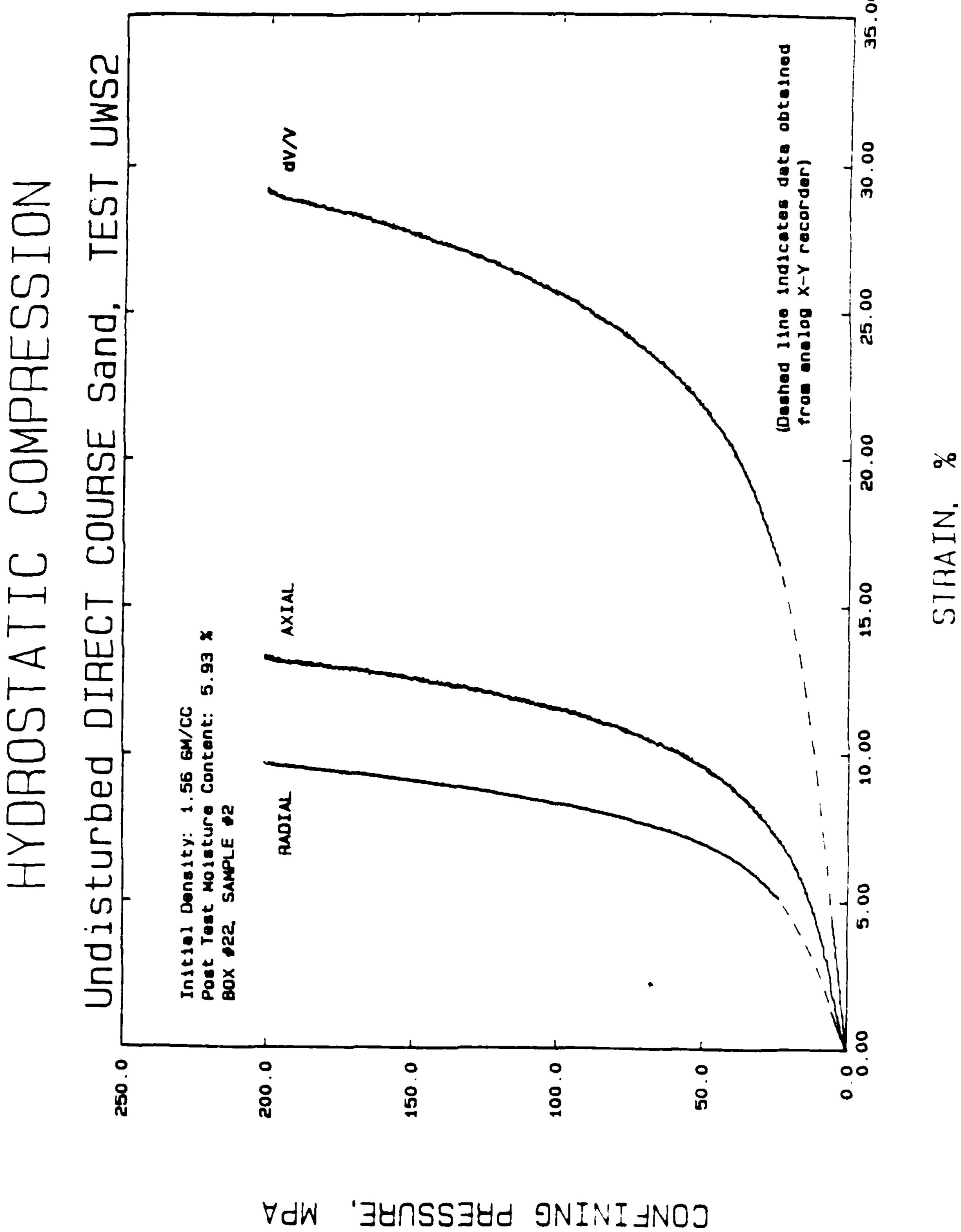
Plate 77


HYDROSTATIC COMPRESSION
Undisturbed DIRECT COURSE Sand, TEST UWS1
Initial Density: 1.63 GM/CC
Post Test Moisture Content: 5.82 %
BOX #23, SAMPLE #5
RADIAL
AXIAL
dV/V
CONFINING PRESSURE, MPA
0.0
50.0
100.0
150.0
200.0
250.0
STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00



TRIAXIAL COMPRESSION
Undisturbed DIRECT COURSE Sand, TEST UWS1
Initial Density: 1.63 GM/CC
Post Test Moisture Content: 5.82 %
BOX #23, SAMPLE #5
RADIAL
AXIAL
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-30.0
-20.0
-10.0
0.0
10.0
20.0
30.0
STRESS DIFFERENCE, MPA
STRAIN, %

Plate 79



HYDROSTATIC COMPRESSION
Undisturbed DIRECT COURSE Sand, TEST UWS2
Initial Density: 1.56 GM/CC
Post Test Moisture Content: 5.93 %
BOX #22, SAMPLE #2
RADIAL
AXIAL
dV/V
(Dashed line indicates data obtained from analog X-Y recorder)
CONFINING PRESSURE, MPA
0.0
50.0
100.0
150.0
200.0
250.0
STRAIN, %
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

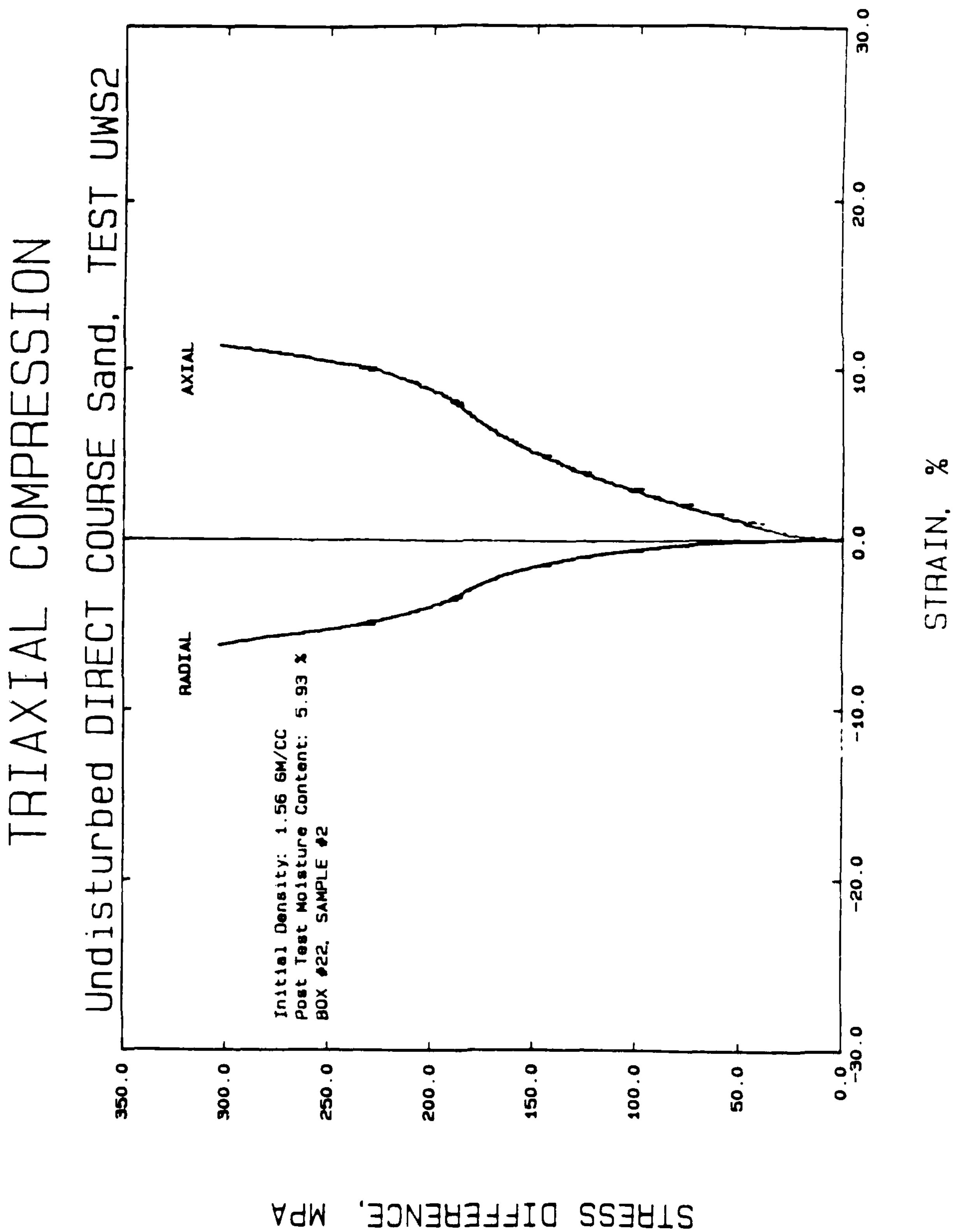
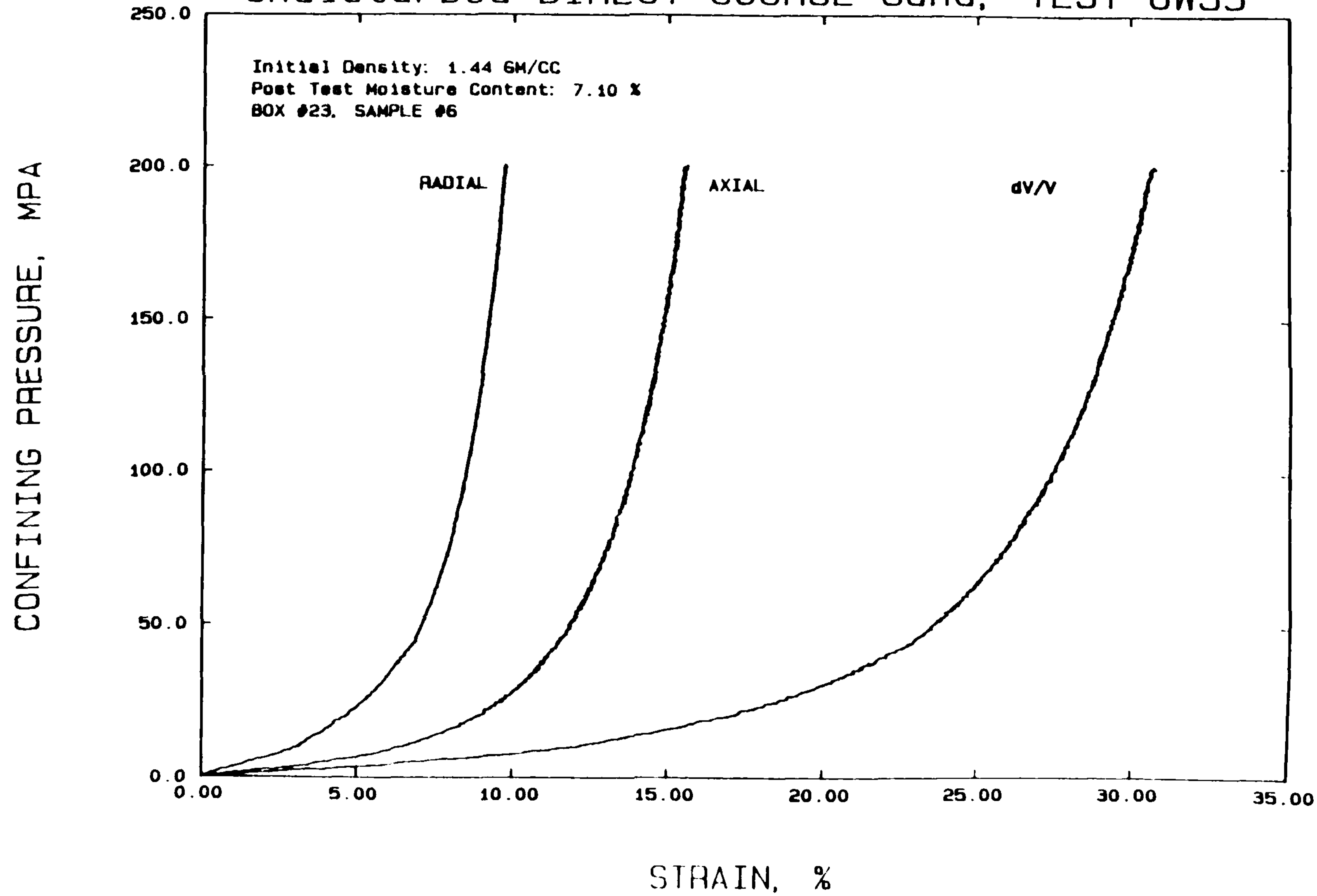

TRIAXIAL COMPRESSION
Undisturbed DIRECT COURSE Sand, TEST UWS2
AXIAL
RADIAL
Initial Density: 1.56 GM/CC
Post Test Moisture Content: 5.93 %
BOX #22, SAMPLE #2
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
STRAIN, %
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
STRESS DIFFERENCE, MPA

Plate 81

HYDROSTATIC COMPRESSION

Undisturbed DIRECT COURSE Sand, TEST UWS3



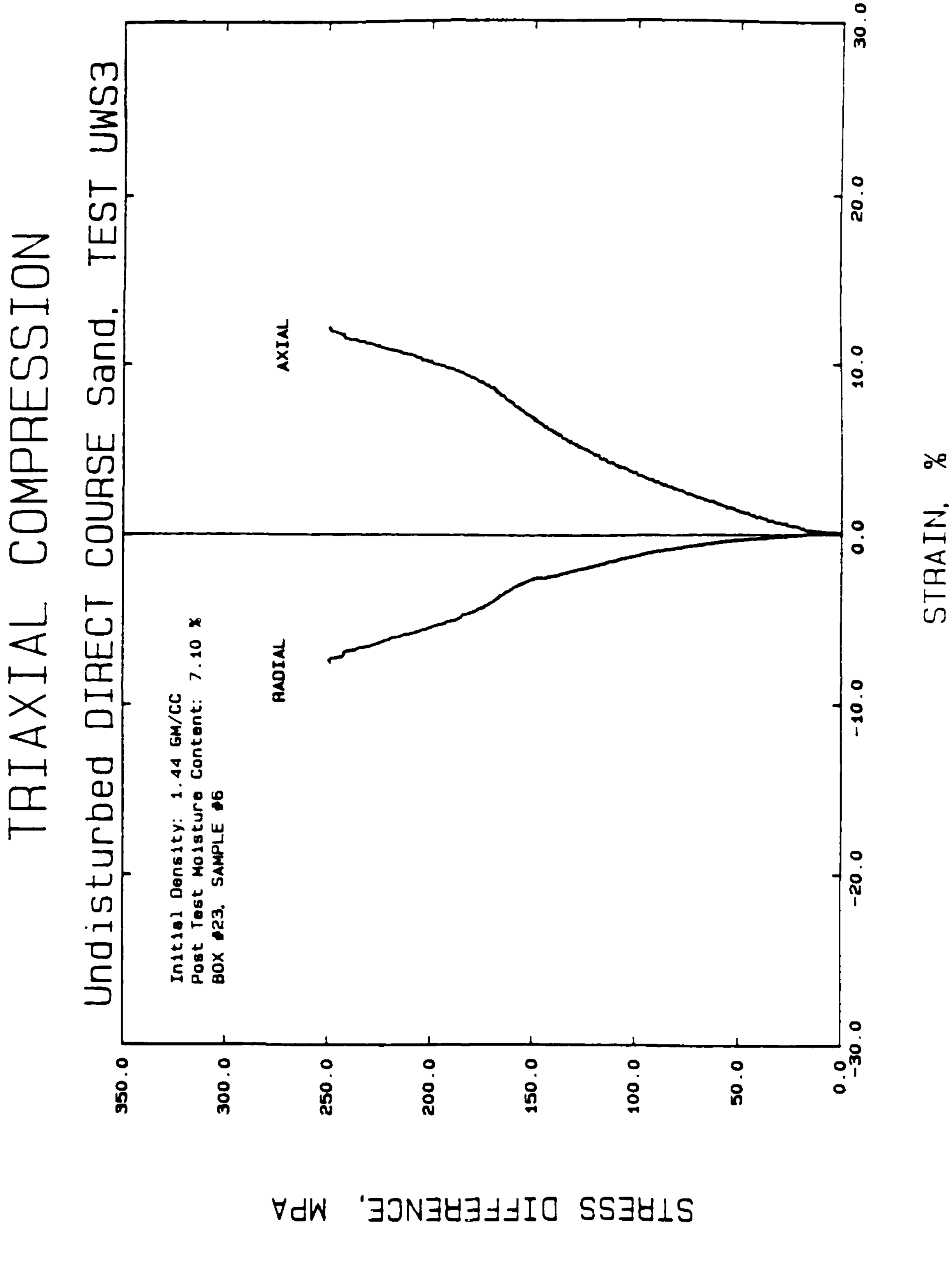
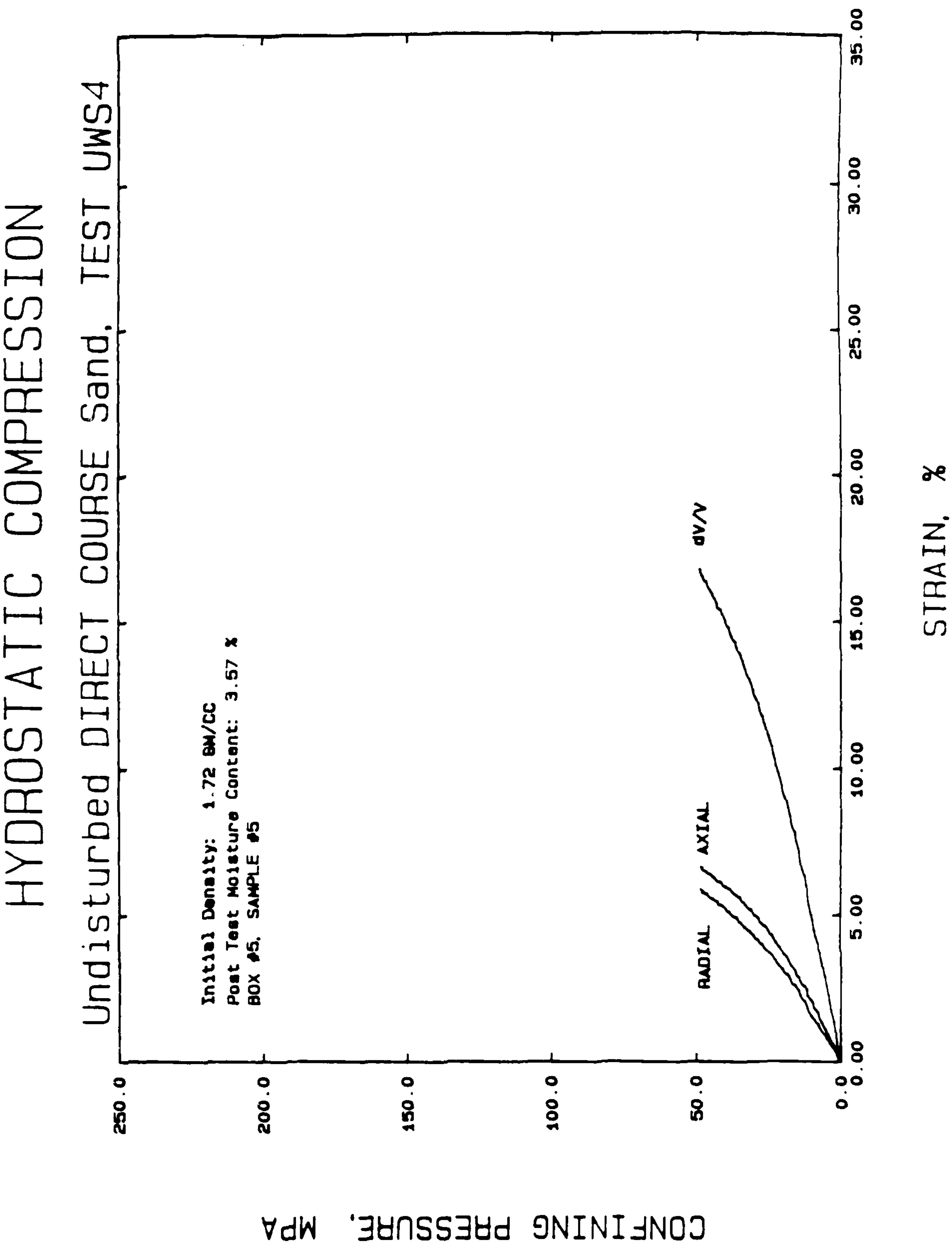
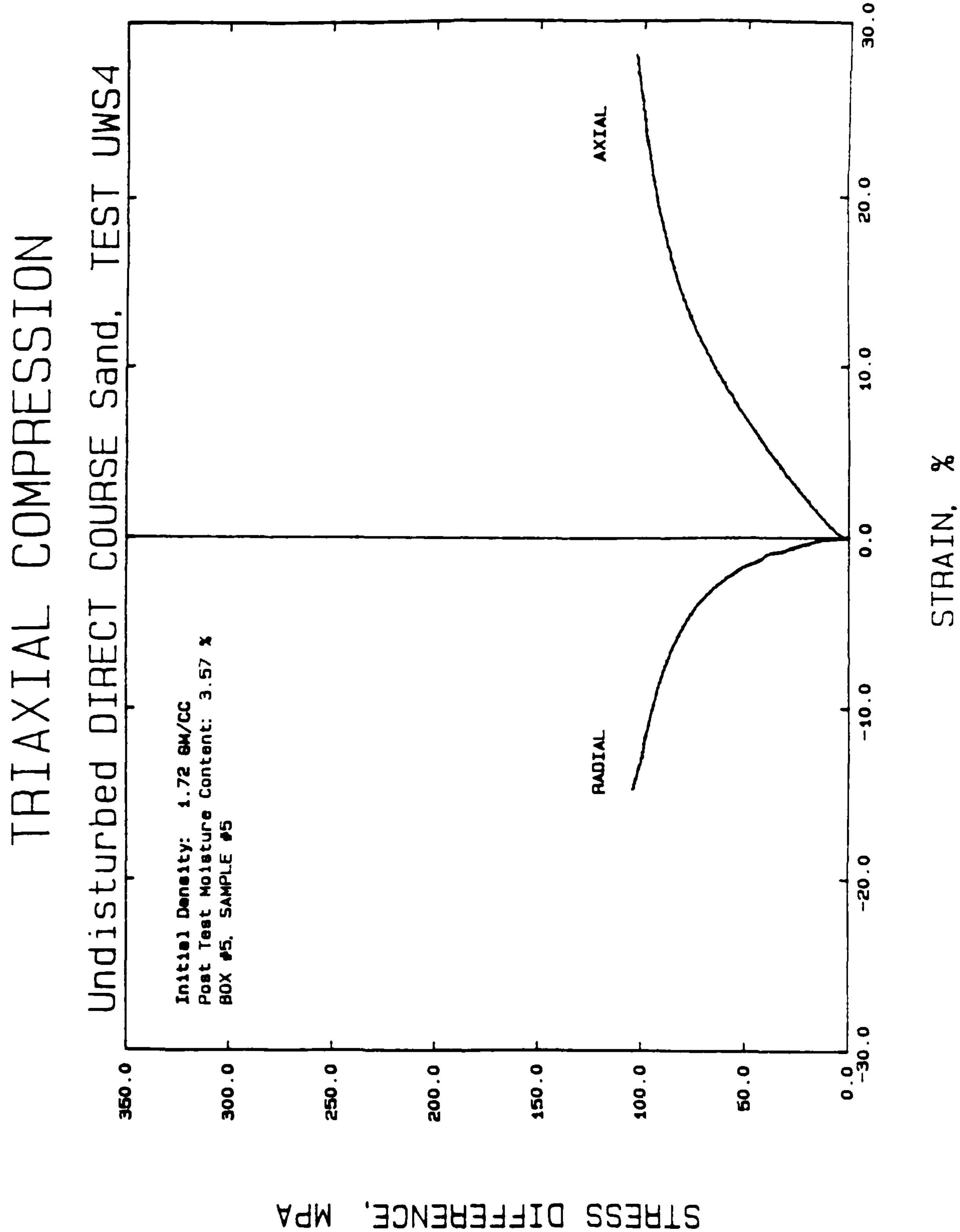

TRIAXIAL COMPRESSION
Undisturbed DIRECT COURSE Sand. TEST UWS3
Initial Density: 1.44 GM/CC
Post Test Moisture Content: 7.10 %
BOX #23, SAMPLE #6
AXIAL
RADIAL
STRESS DIFFERENCE, MPA
STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
-30.0
-20.0
-10.0
0.0
10.0
20.0
30.0

Plate 83


HYDROSTATIC COMPRESSION
Undisturbed DIRECT COURSE Sand, TEST UWS4
Initial Density: 1.72 GM/CC
Post Test Moisture Content: 3.57 %
BOX #5, SAMPLE #5
RADIAL
AXIAL
dV/V
CONFINING PRESSURE, MPA
STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00


TRIAXIAL COMPRESSION
Undisturbed DIRECT COURSE Sand, TEST UWS4
Initial Density: 1.72 GM/CC
Post Test Moisture Content: 3.57 %
BOX #5, SAMPLE #5
AXIAL
RADIAL
STRESS DIFFERENCE, MPA
STRAIN, %
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
-30.0
-20.0
-10.0
0.0
10.0
20.0
30.0

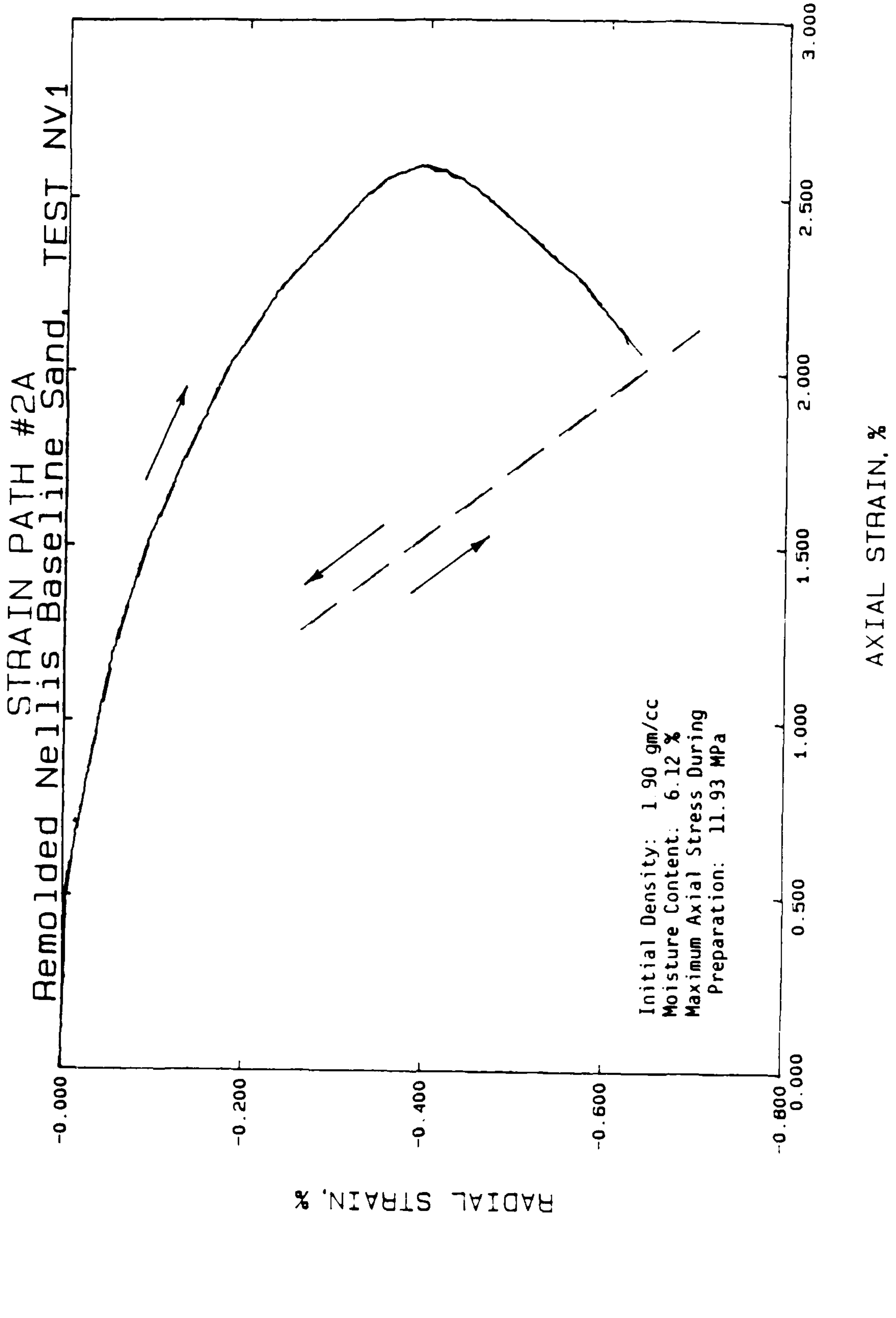

STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.90 gm/cc
Moisture Content: 6.12 %
Maximum Axial Stress During
Preparation: 11.93 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

Plate 86

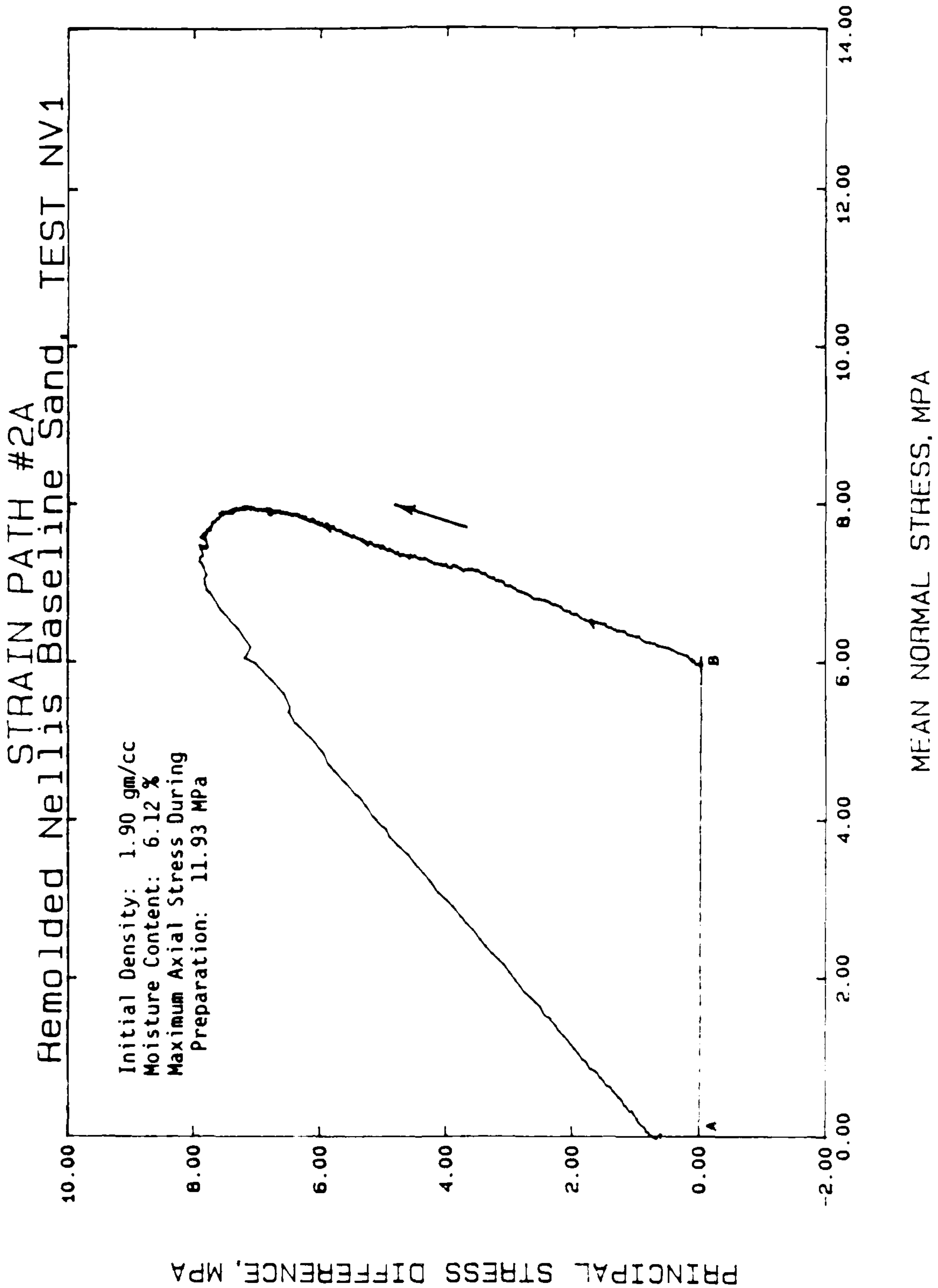
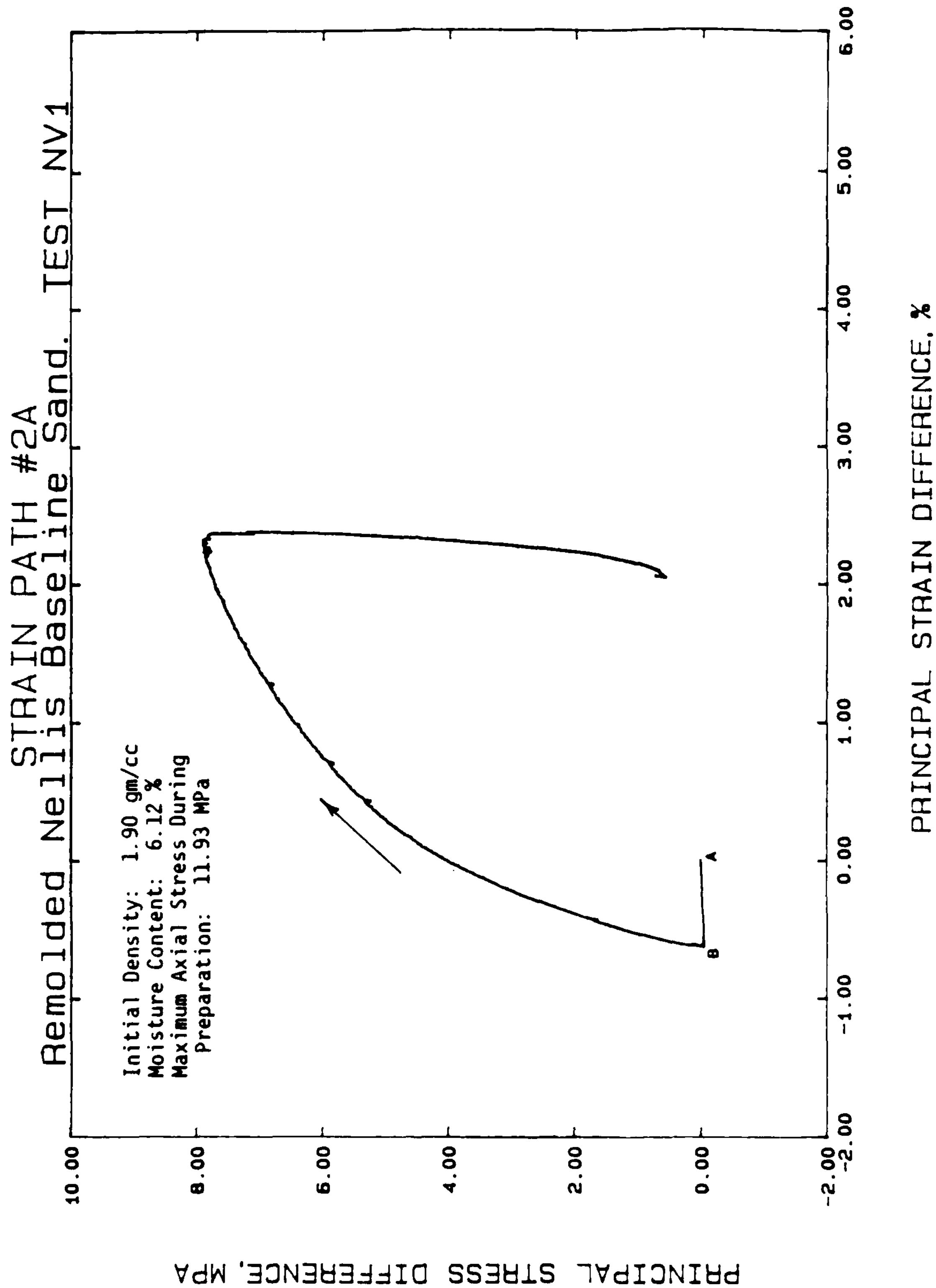

STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.90 gm/cc
Moisture Content: 6.12 %
Maximum Axial Stress During
Preparation: 11.93 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
A
B

Plate 67


STRAIN PATH #2A
Remolded Nellis Baseline Sand. TEST NV1
Initial Density: 1.90 gm/cc
Moisture Content: 6.12 %
Maximum Axial Stress During
Preparation: 11.93 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-1.00
1.00
3.00
5.00

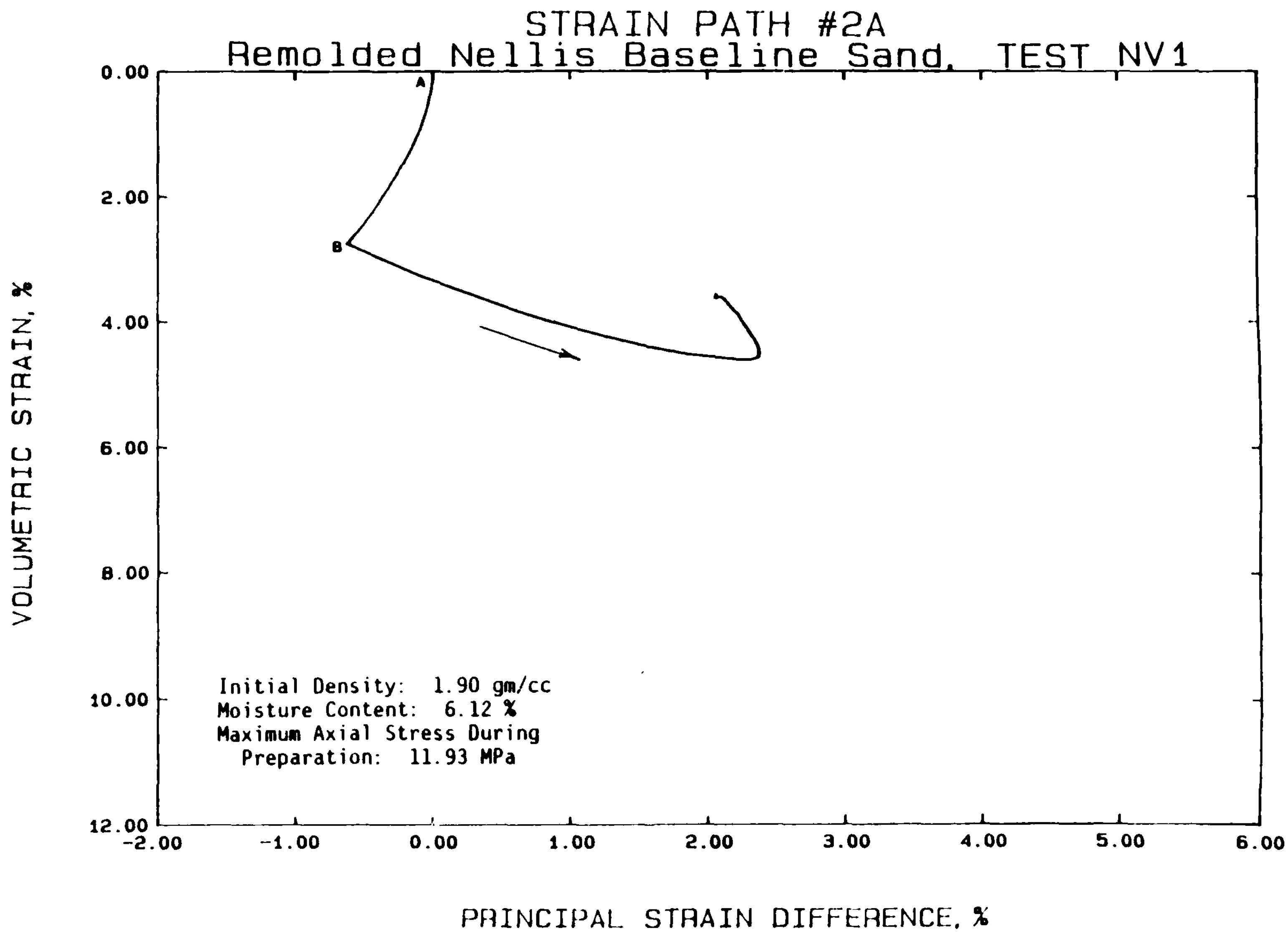

STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV1
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
A
B
Initial Density: 1.90 gm/cc
Moisture Content: 6.12 %
Maximum Axial Stress During
Preparation: 11.93 MPa

Plate 99

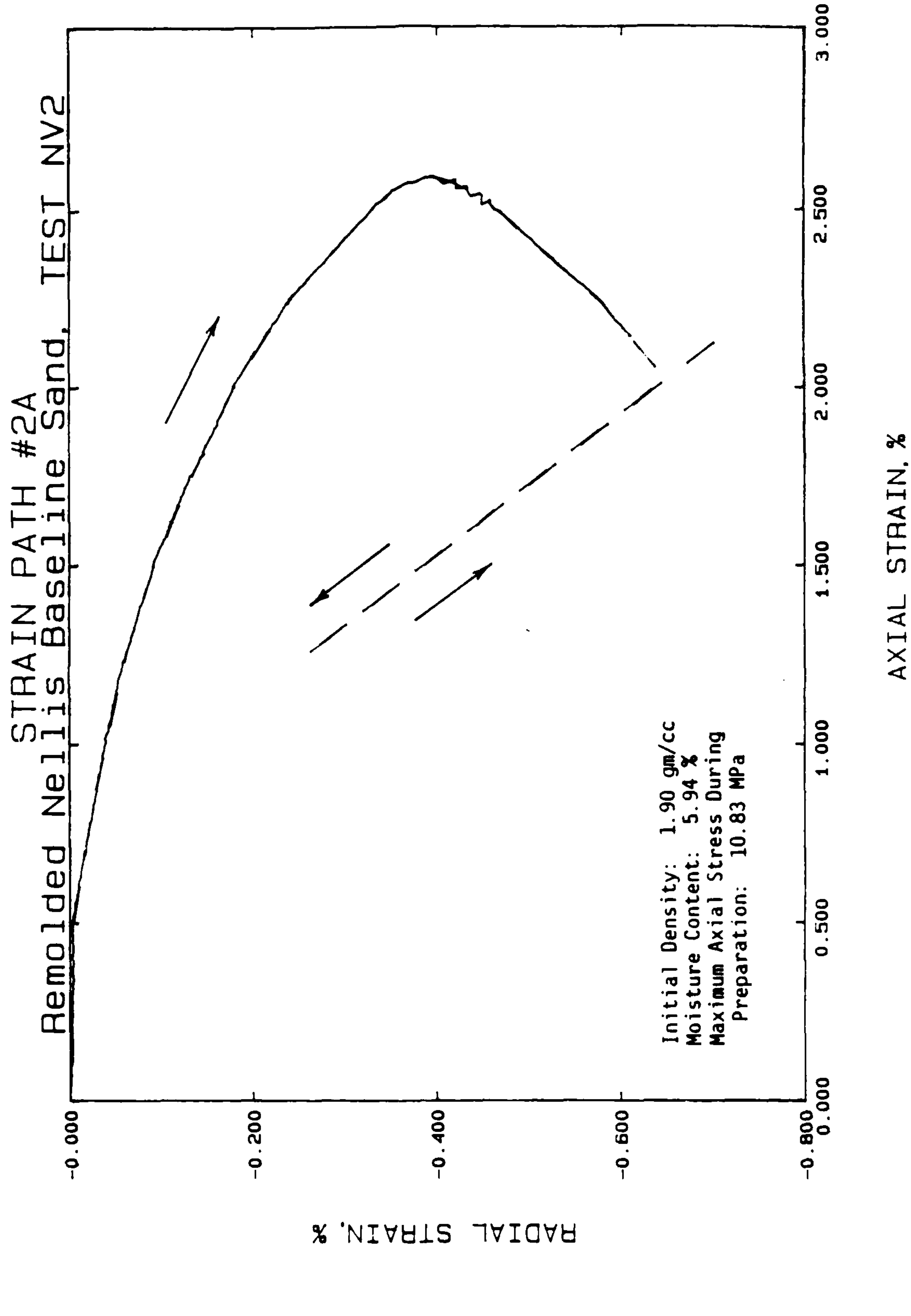

STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.94 %
Maximum Axial Stress During
Preparation: 10.83 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

Plate 90

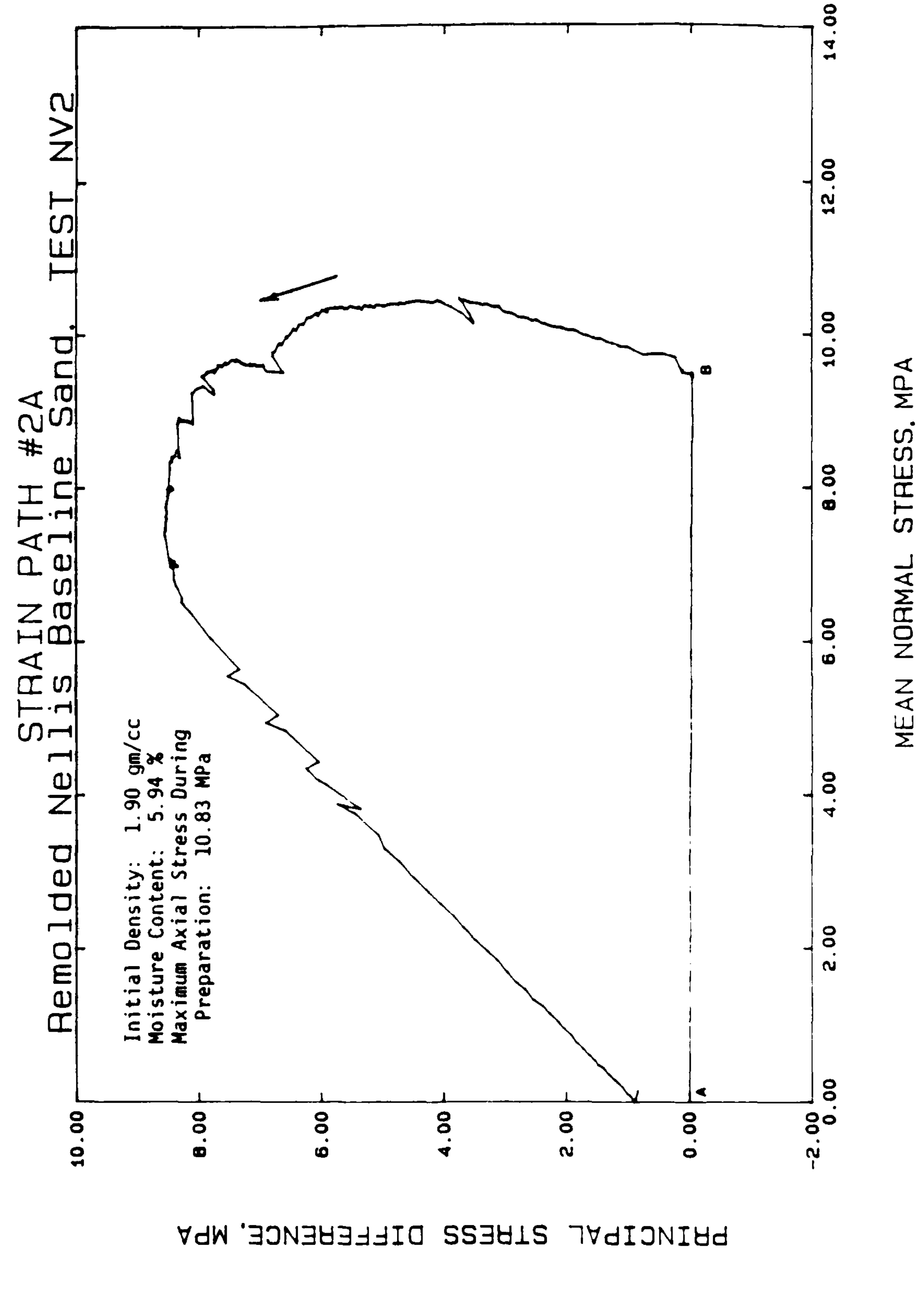
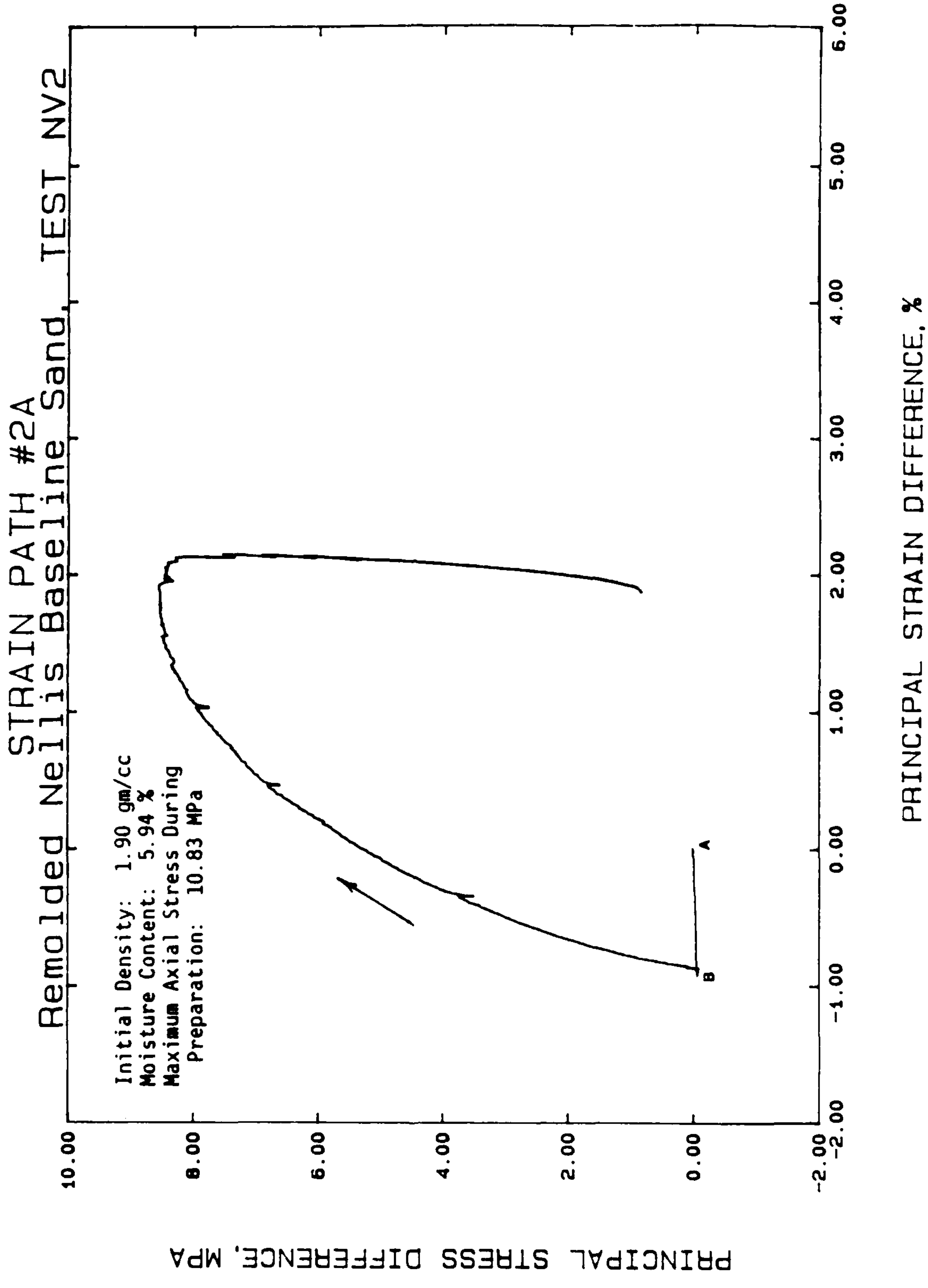

STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.94 %
Maximum Axial Stress During
Preparation: 10.83 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
MEAN NORMAL STRESS, MPA
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 91



STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.94 %
Maximum Axial Stress During
Preparation: 10.83 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
A
B
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00

Plate 92

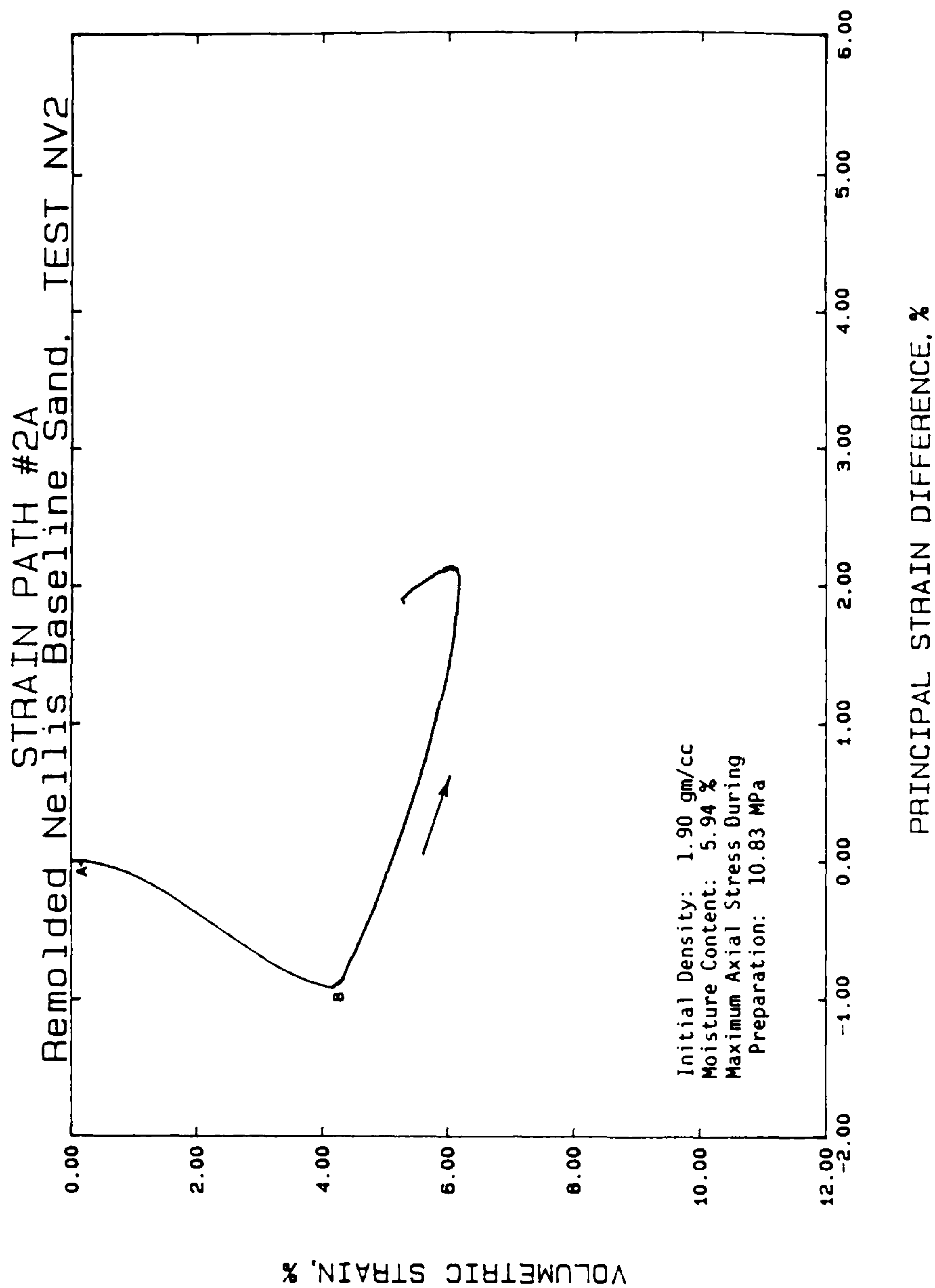
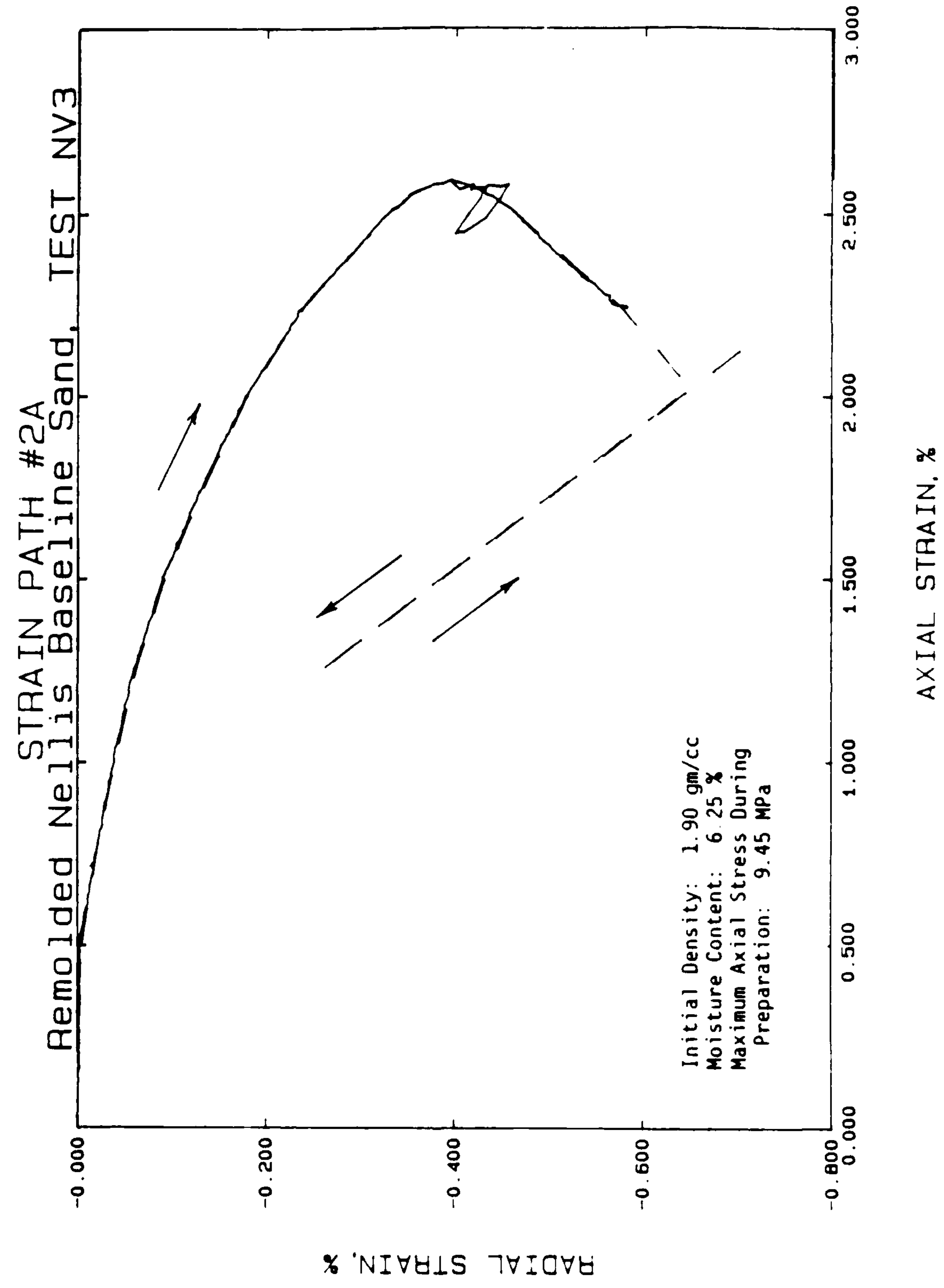
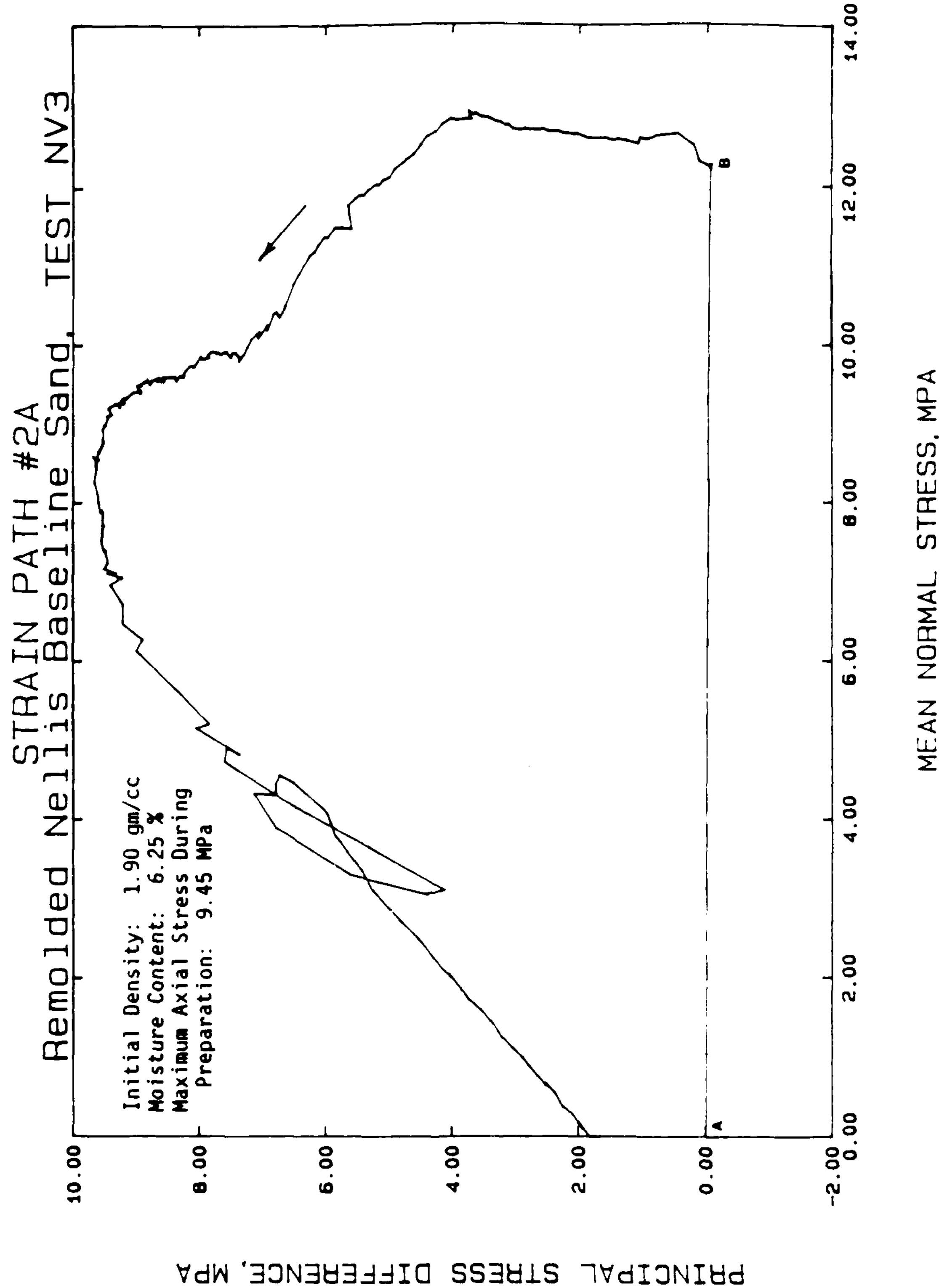

STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.94 %
Maximum Axial Stress During
Preparation: 10.83 MPa
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %

Plate 93



STRAIN PATH #2A
Remoulded Nellis Baseline Sand, TEST NV3
Initial Density: 1.90 gm/cc
Moisture Content: 6.25 %
Maximum Axial Stress During
Preparation: 9.45 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

Plate 94


STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV3
Initial Density: 1.90 gm/cc
Moisture Content: 6.25 %
Maximum Axial Stress During
Preparation: 9.45 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
MEAN NORMAL STRESS, MPA
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

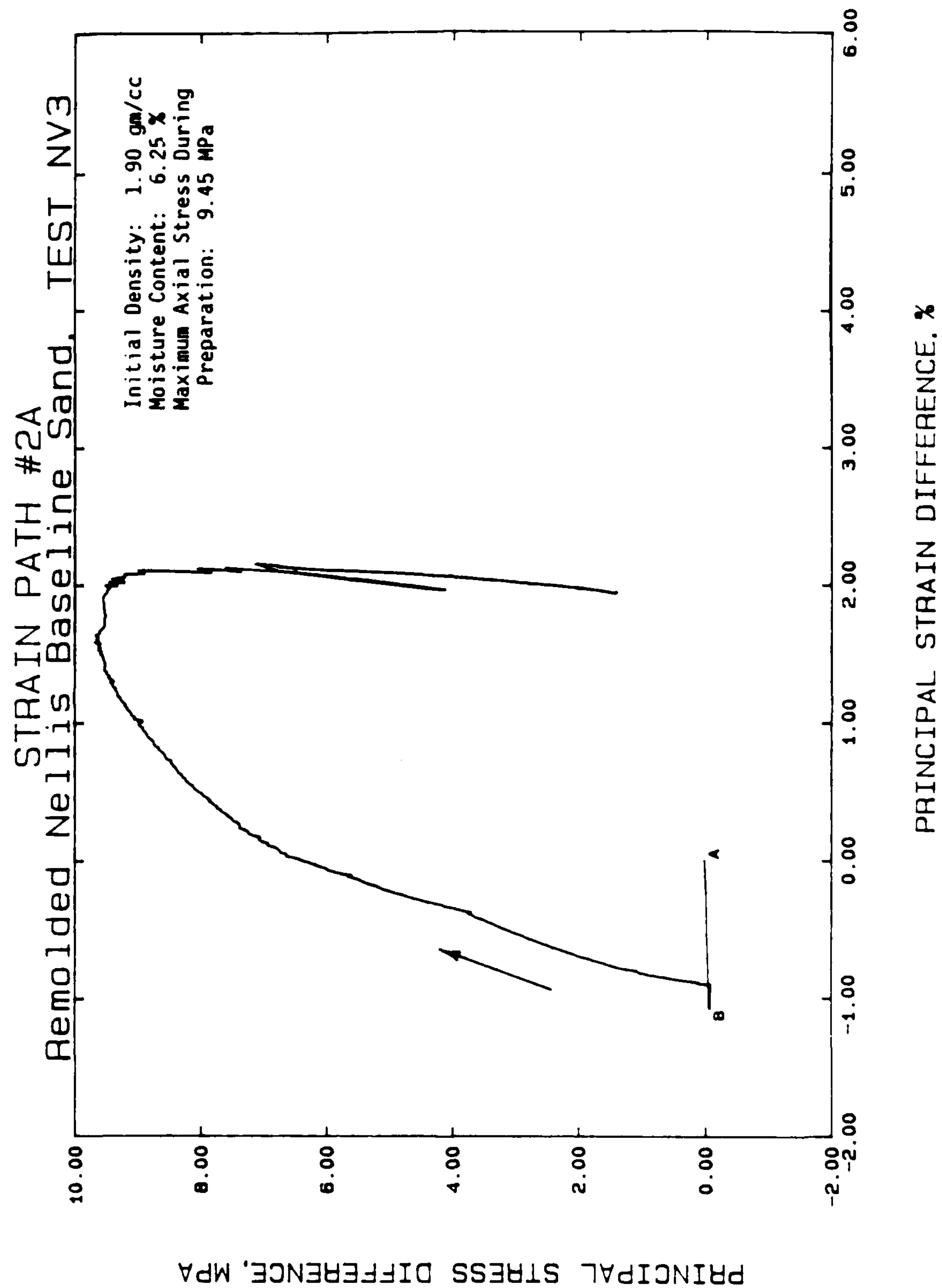
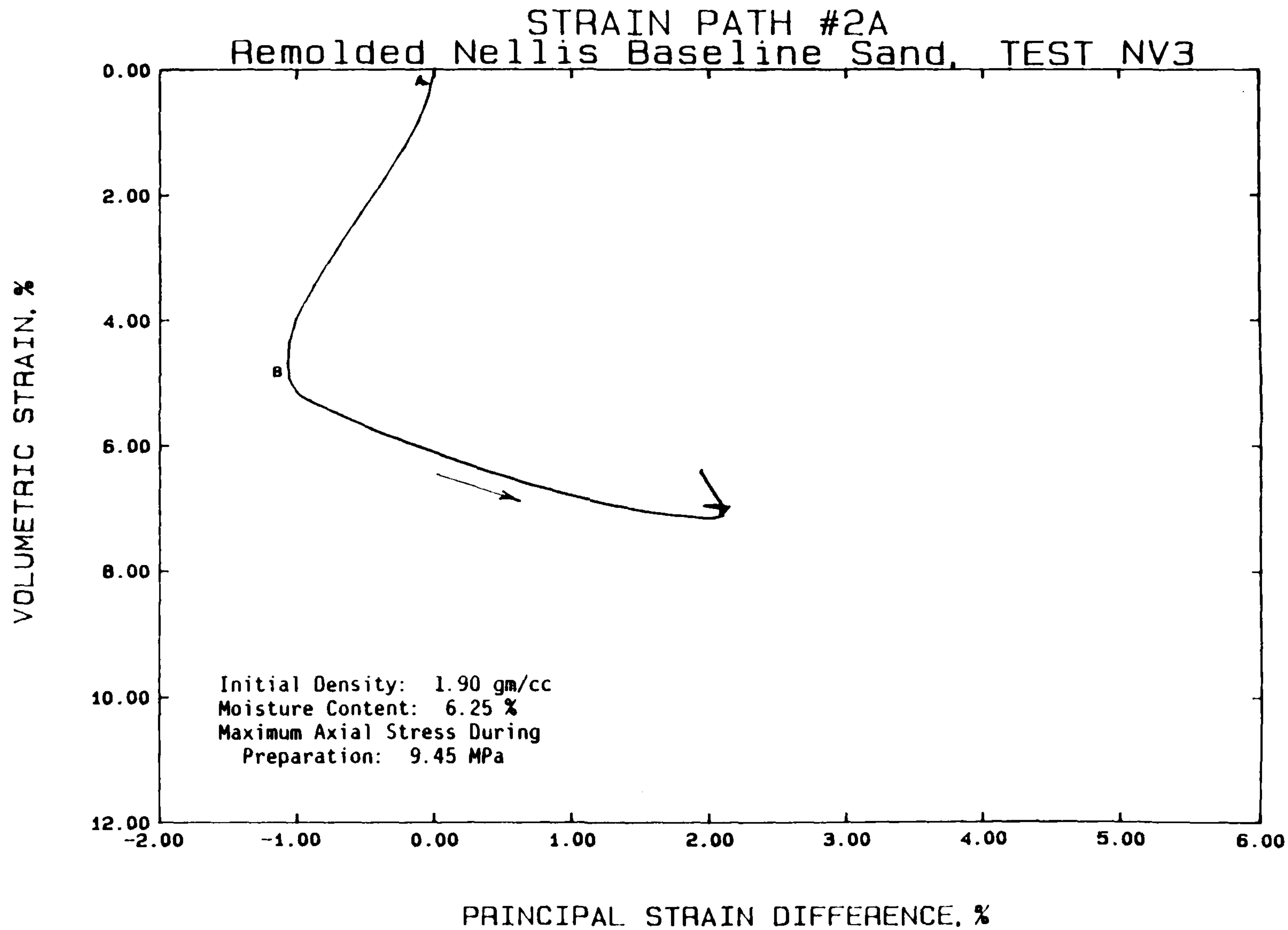

STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV3
Initial Density: 1.90 gm/cc
Moisture Content: 6.25 %
Maximum Axial Stress During
Preparation: 9.45 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00

Plate 96



STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV3
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
A
B
Initial Density: 1.90 gm/cc
Moisture Content: 6.25 %
Maximum Axial Stress During
Preparation: 9.45 MPa

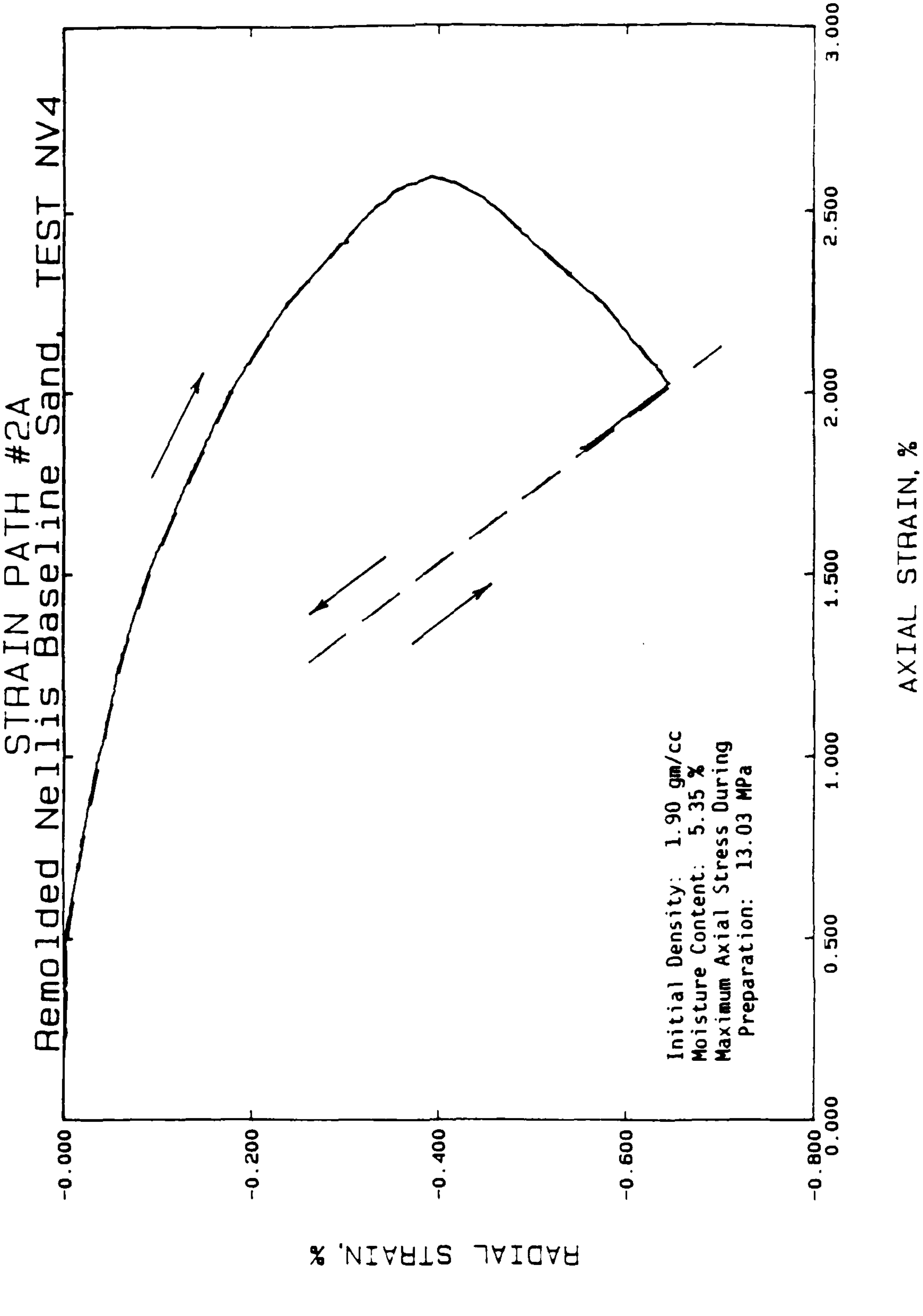

STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 5.35 %
Maximum Axial Stress During
Preparation: 13.03 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

Plate 98

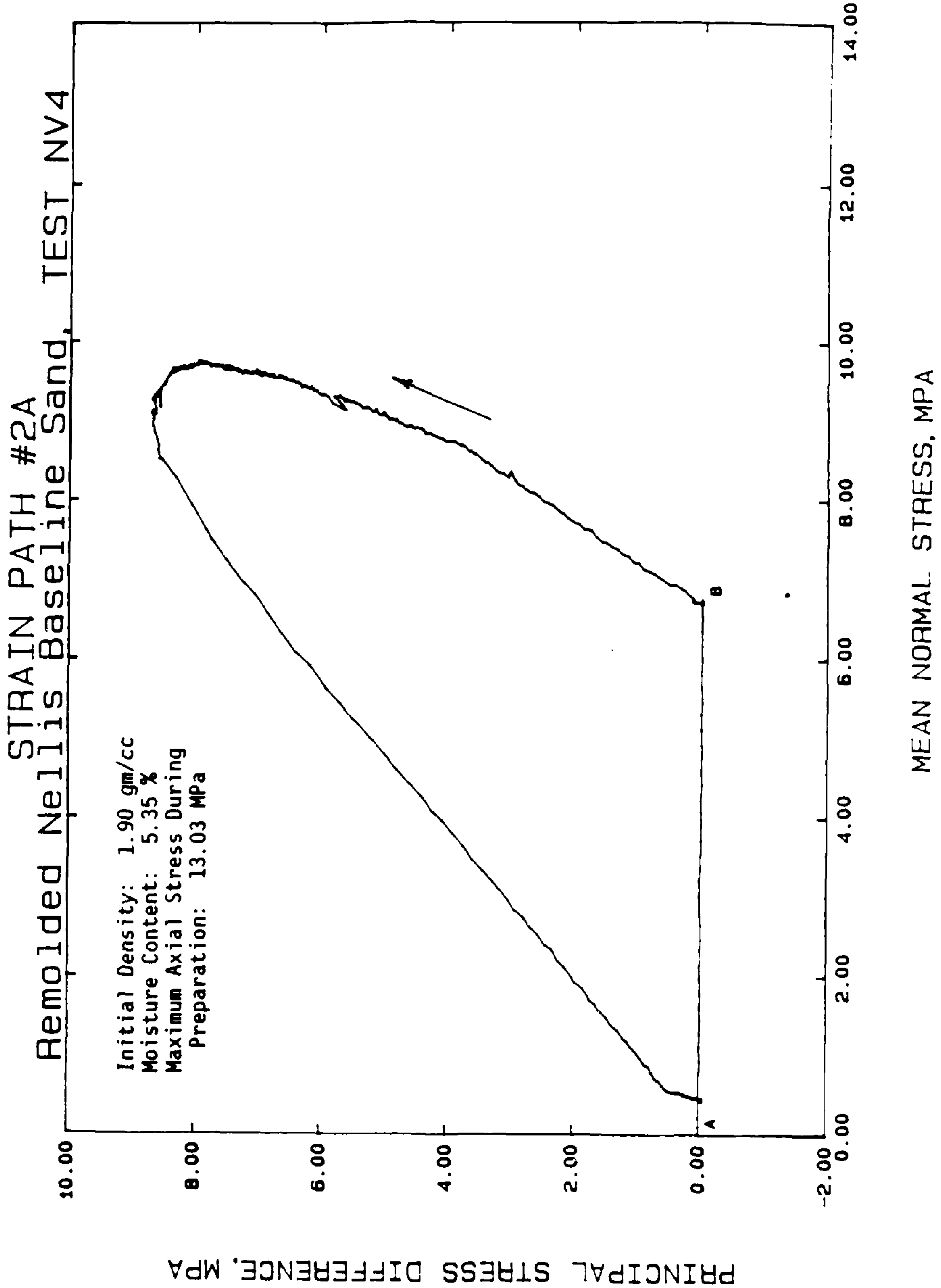
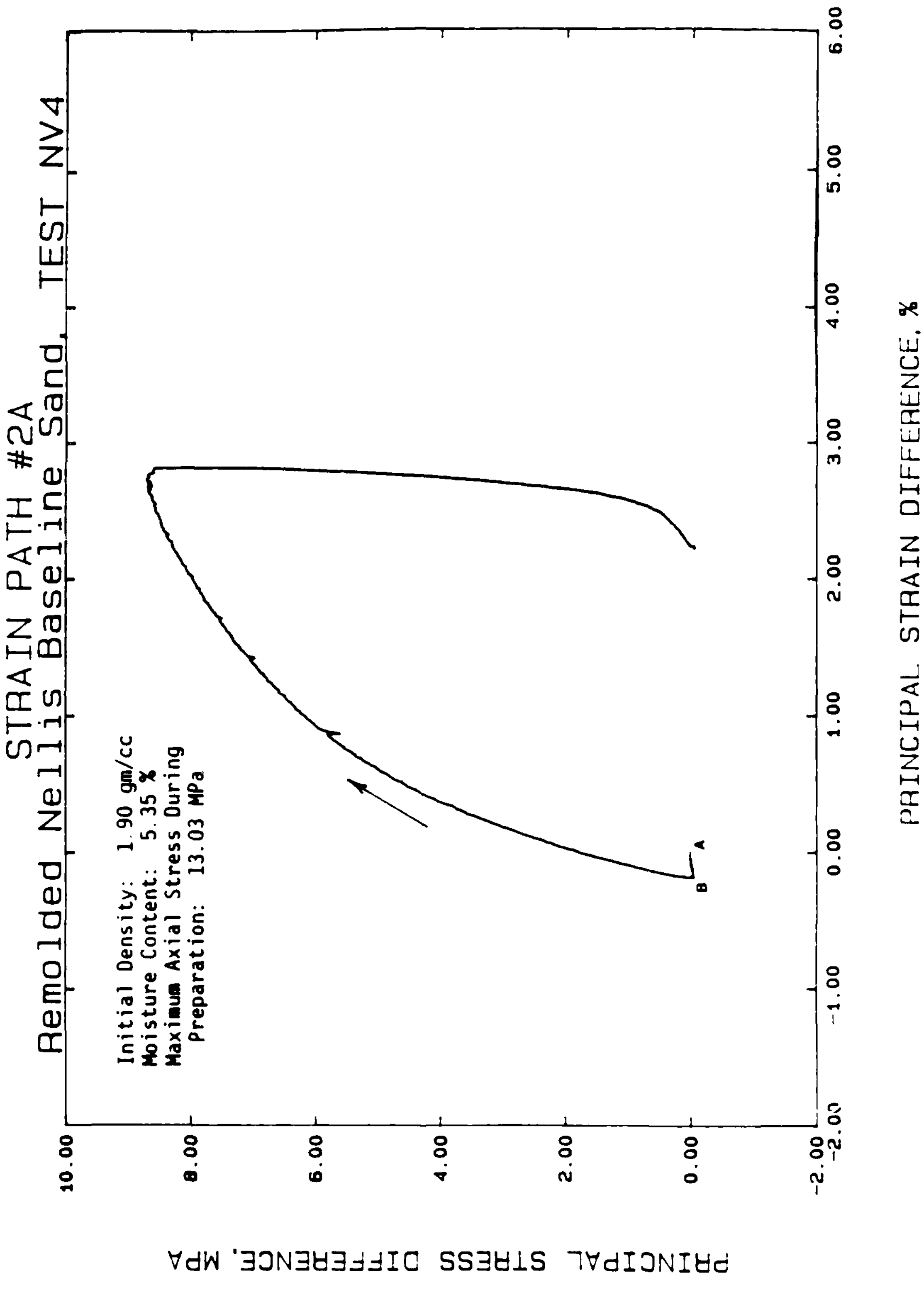
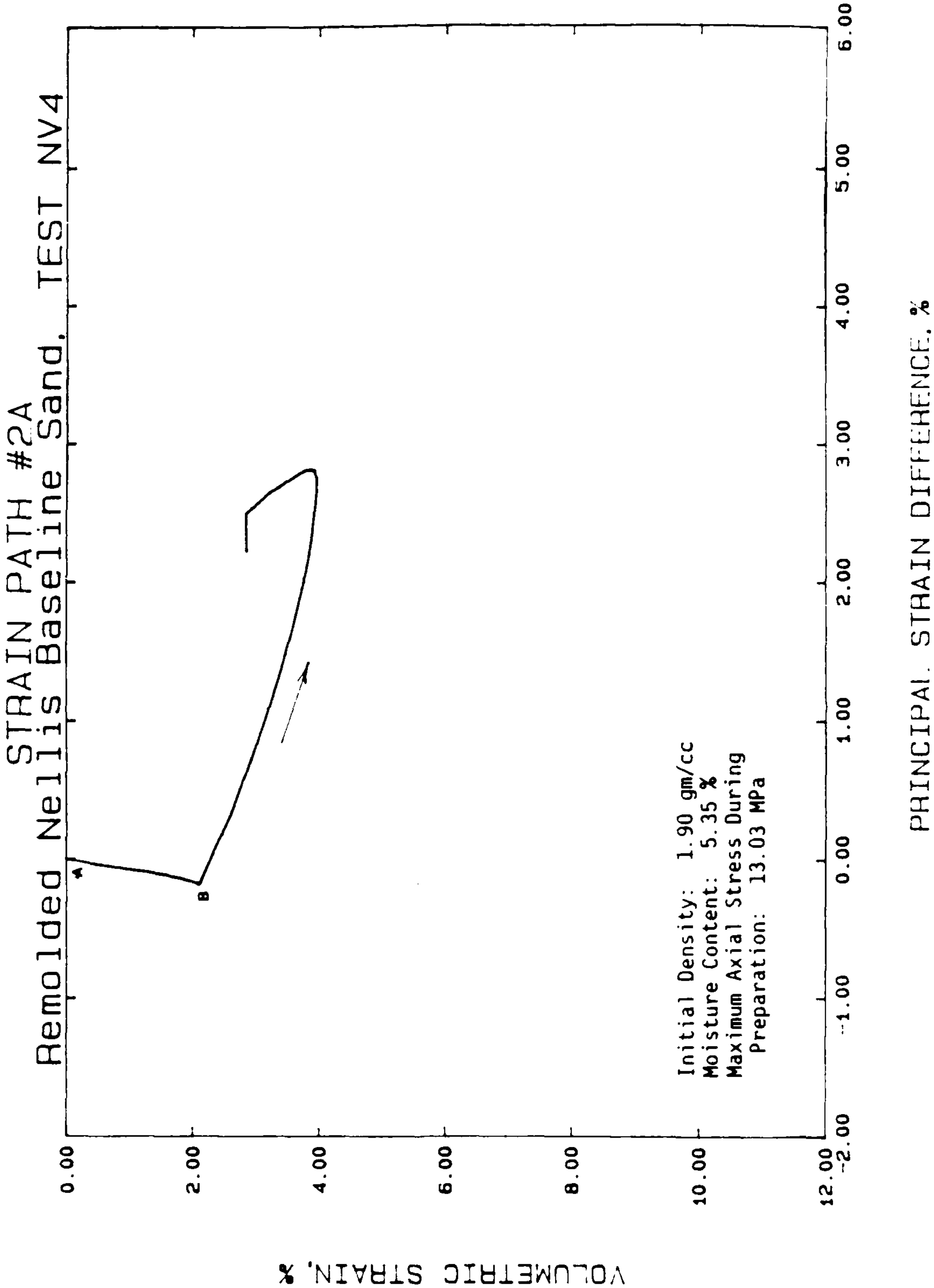
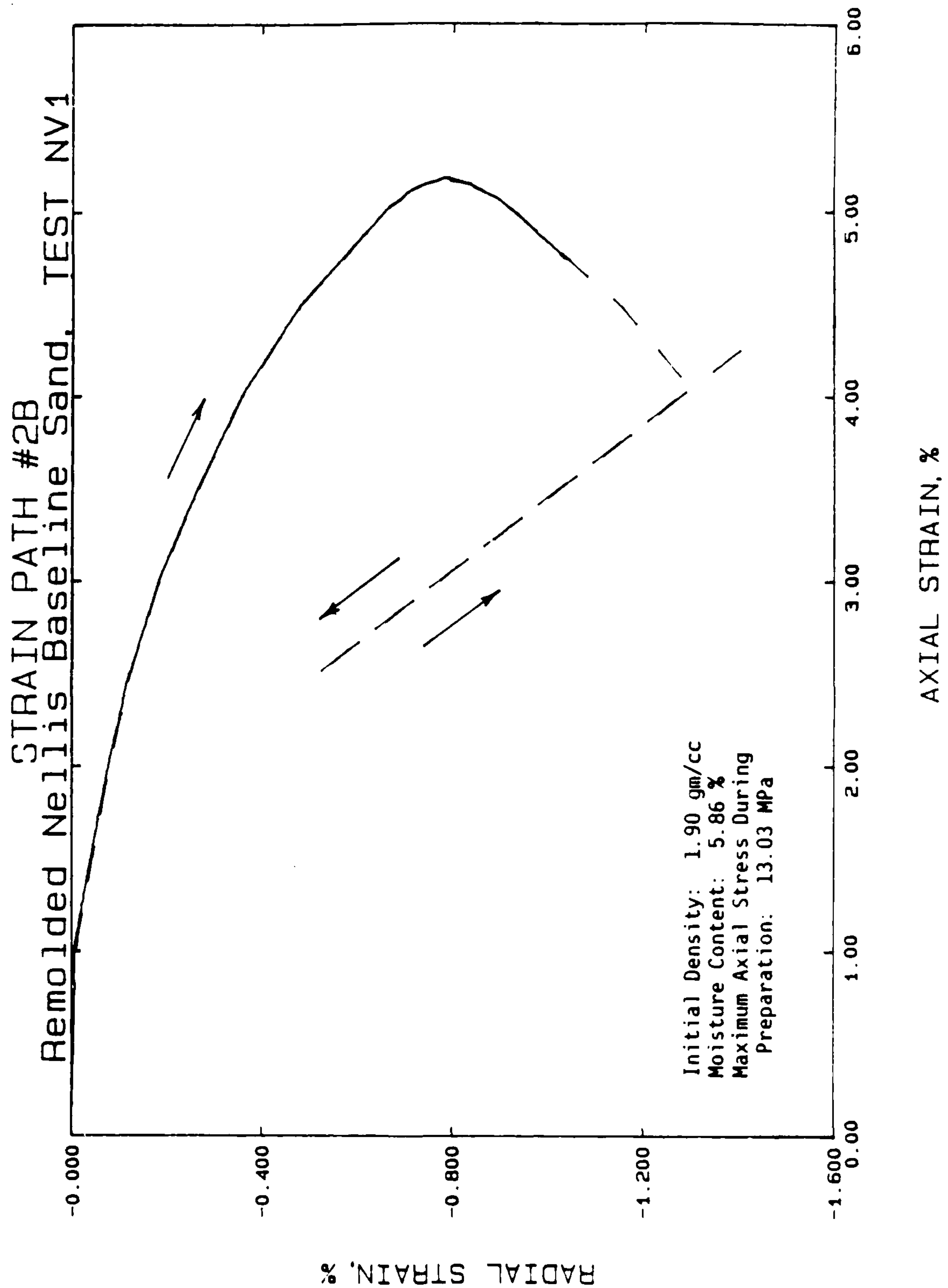

STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 5.35 %
Maximum Axial Stress During
Preparation: 13.03 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 99


STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 5.35 %
Maximum Axial Stress During
Preparation: 13.03 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-1.00
1.00
3.00
5.00



STRAIN PATH #2A
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 5.35 %
Maximum Axial Stress During
Preparation: 13.03 MPa
A
B
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00


STRAIN PATH #2B
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.90 gm/cc
Moisture Content: 5.86 %
Maximum Axial Stress During
Preparation: 13.03 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
-0.000
-0.400
-0.800
-1.200
-1.600

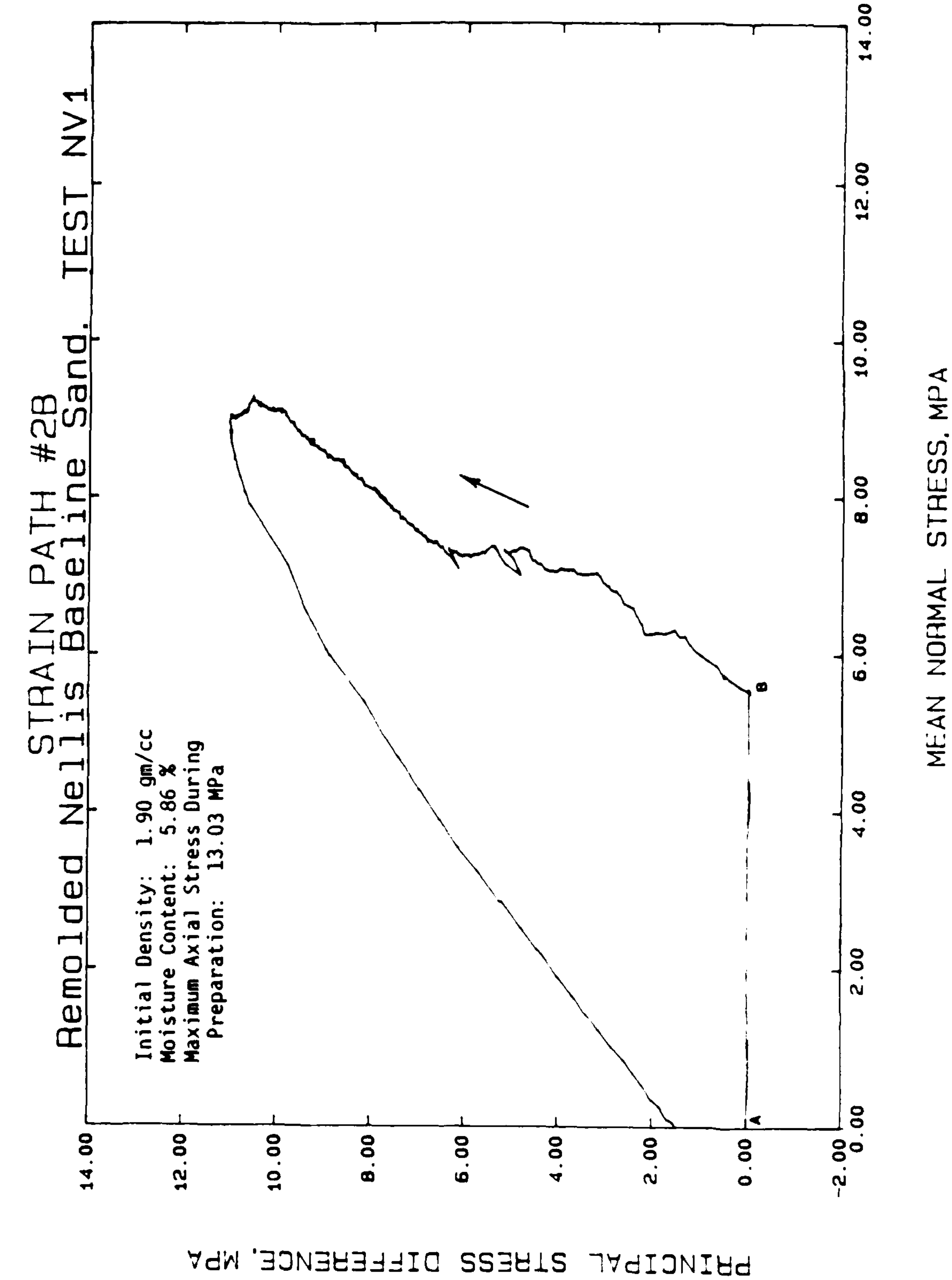

STRAIN PATH #2B
Remolded Nellis Baseline Sand. TEST NV1
Initial Density: 1.90 gm/cc
Moisture Content: 5.86 %
Maximum Axial Stress During
Preparation: 13.03 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00

Plate 103

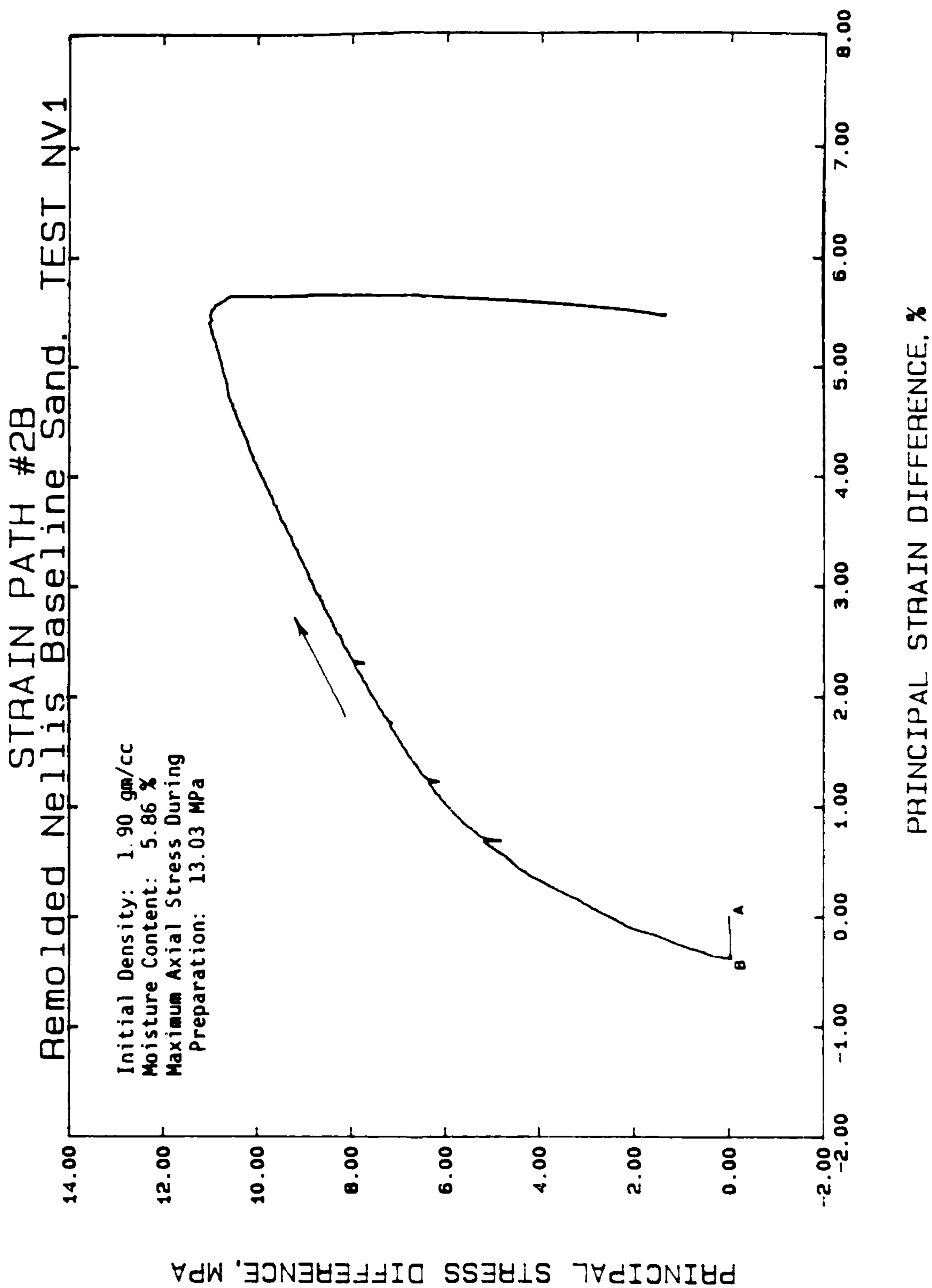

STRAIN PATH #2B
Remolded Nellis Baseline Sand. TEST NV1
Initial Density: 1.90 gm/cc
Moisture Content: 5.86 %
Maximum Axial Stress During
Preparation: 13.03 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
PRINCIPAL STRAIN DIFFERENCE, %

Plate 104

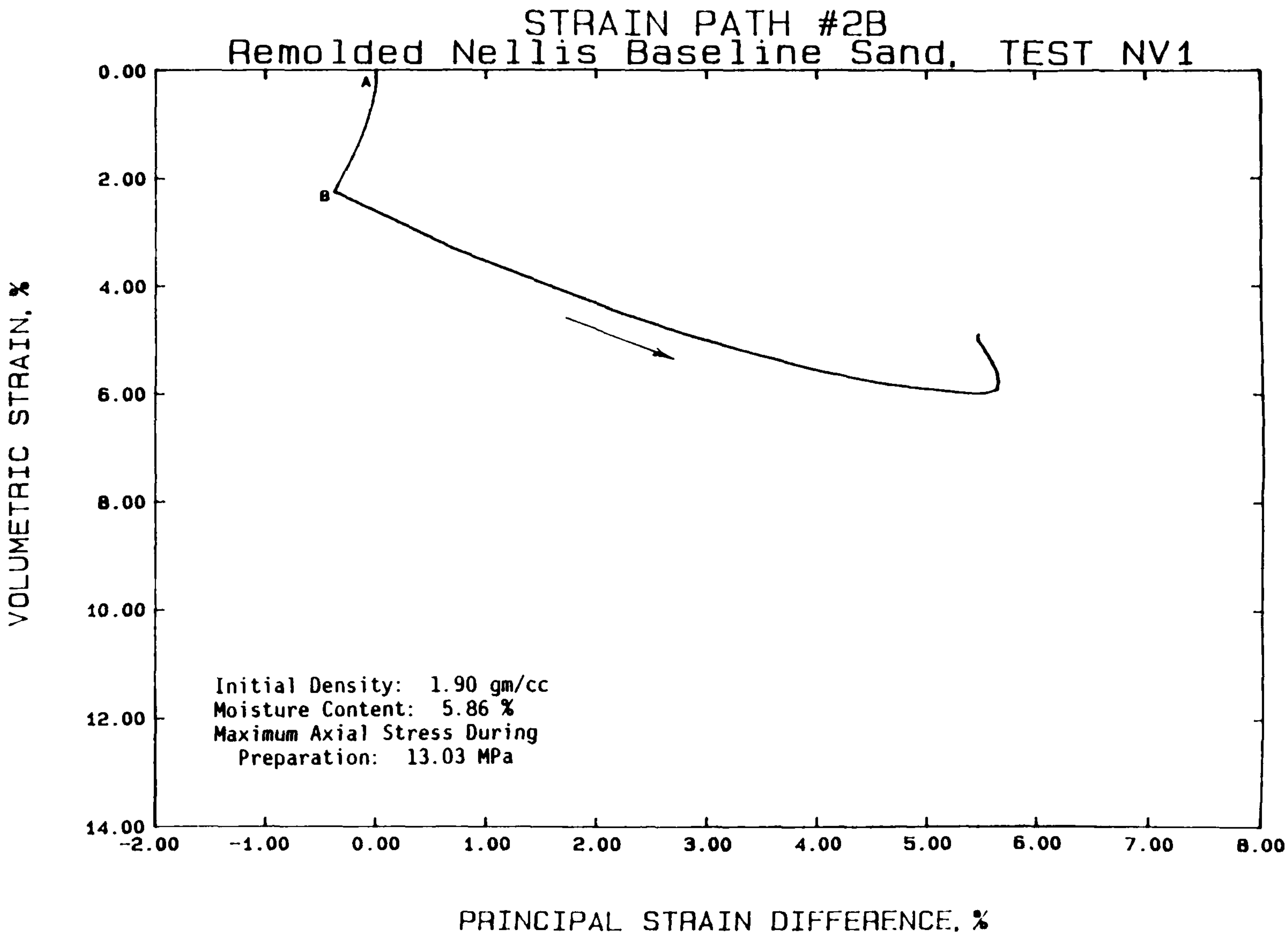

STRAIN PATH #2B
Remolded Nellis Baseline Sand, TEST NV1
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
A
B
Initial Density: 1.90 gm/cc
Moisture Content: 5.86 %
Maximum Axial Stress During
Preparation: 13.03 MPa

Plate 105

STRAIN PATH #2B
Remolded Nellis Baseline Sand, TEST NV2

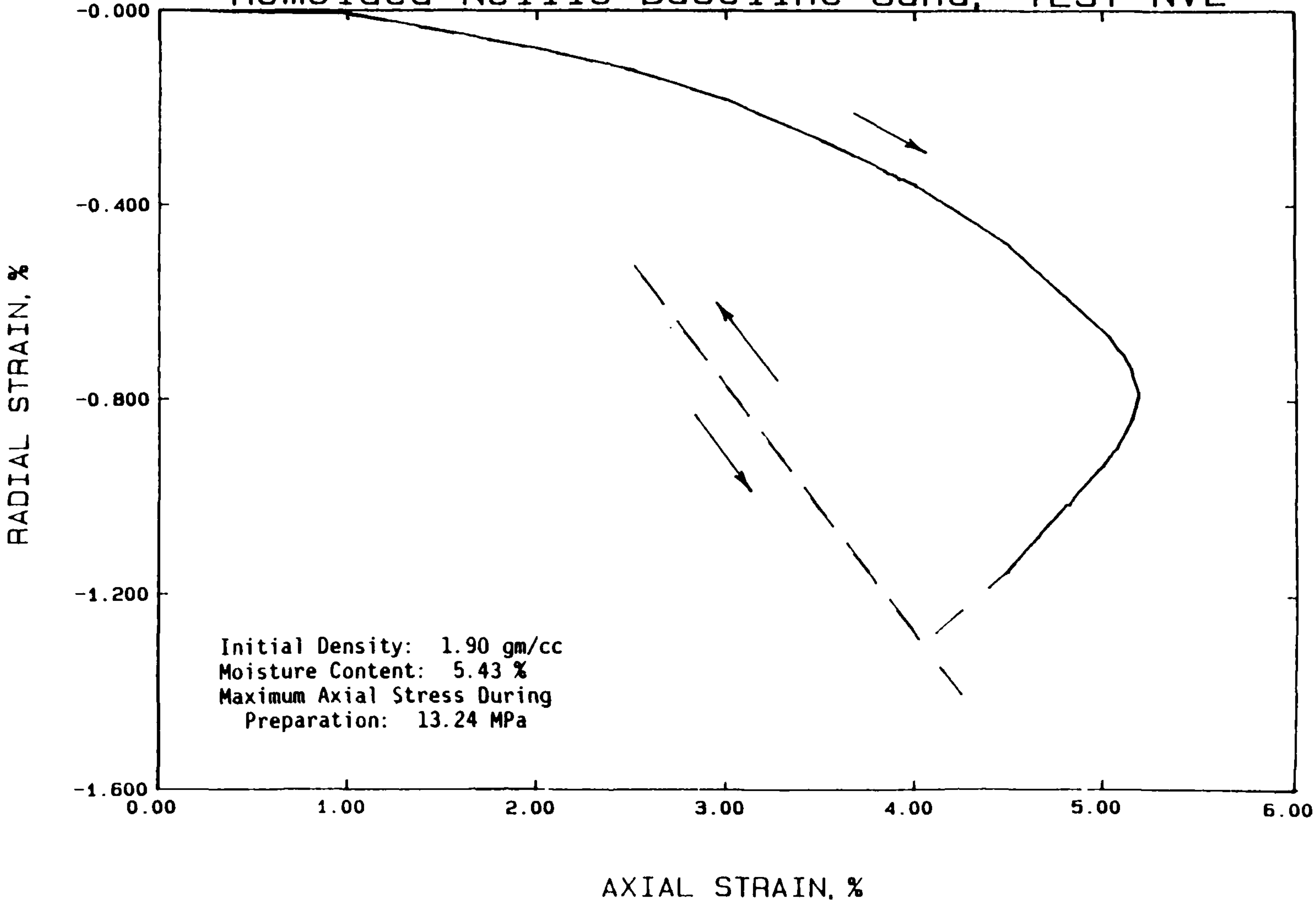


Plate 106

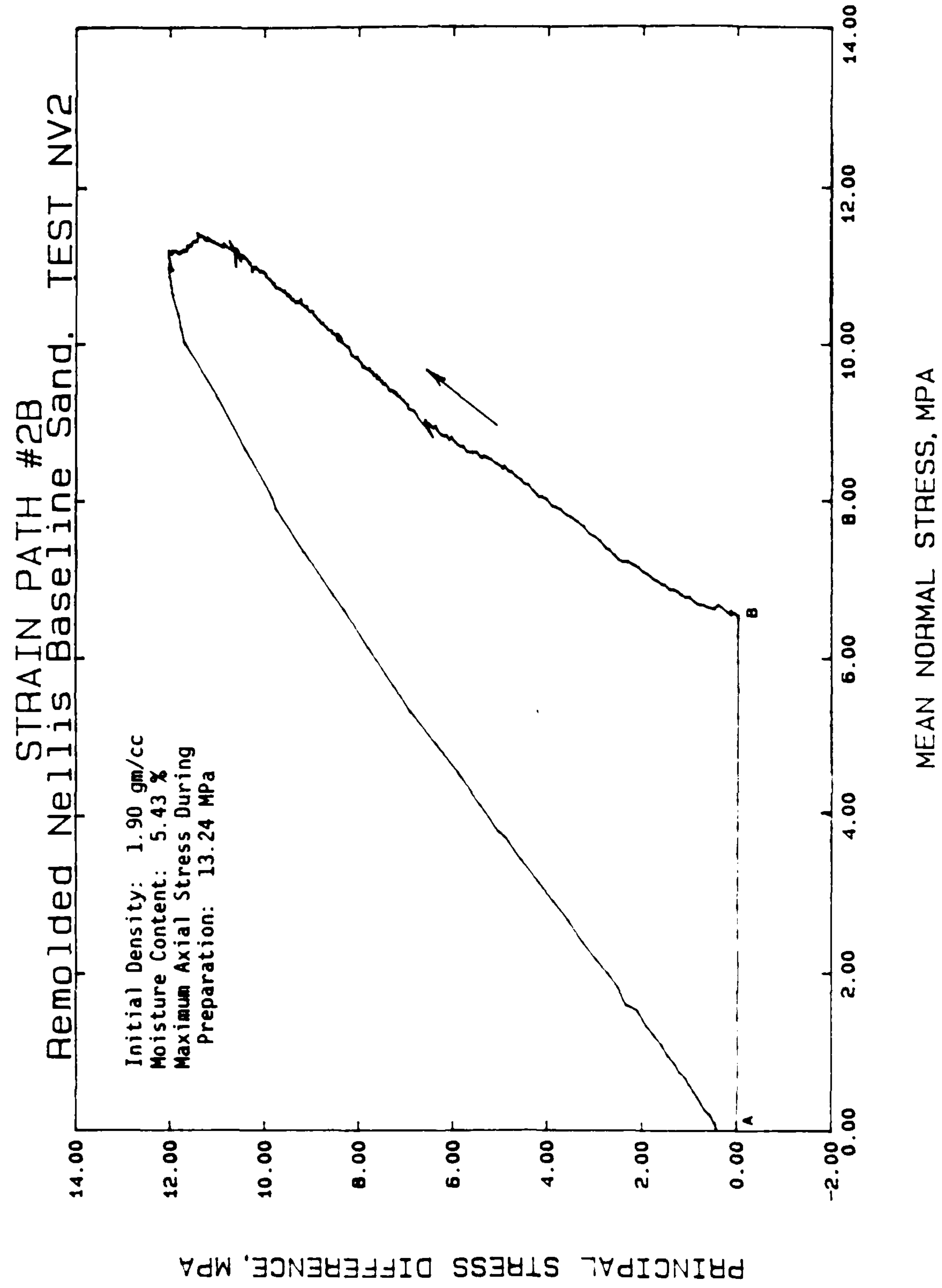
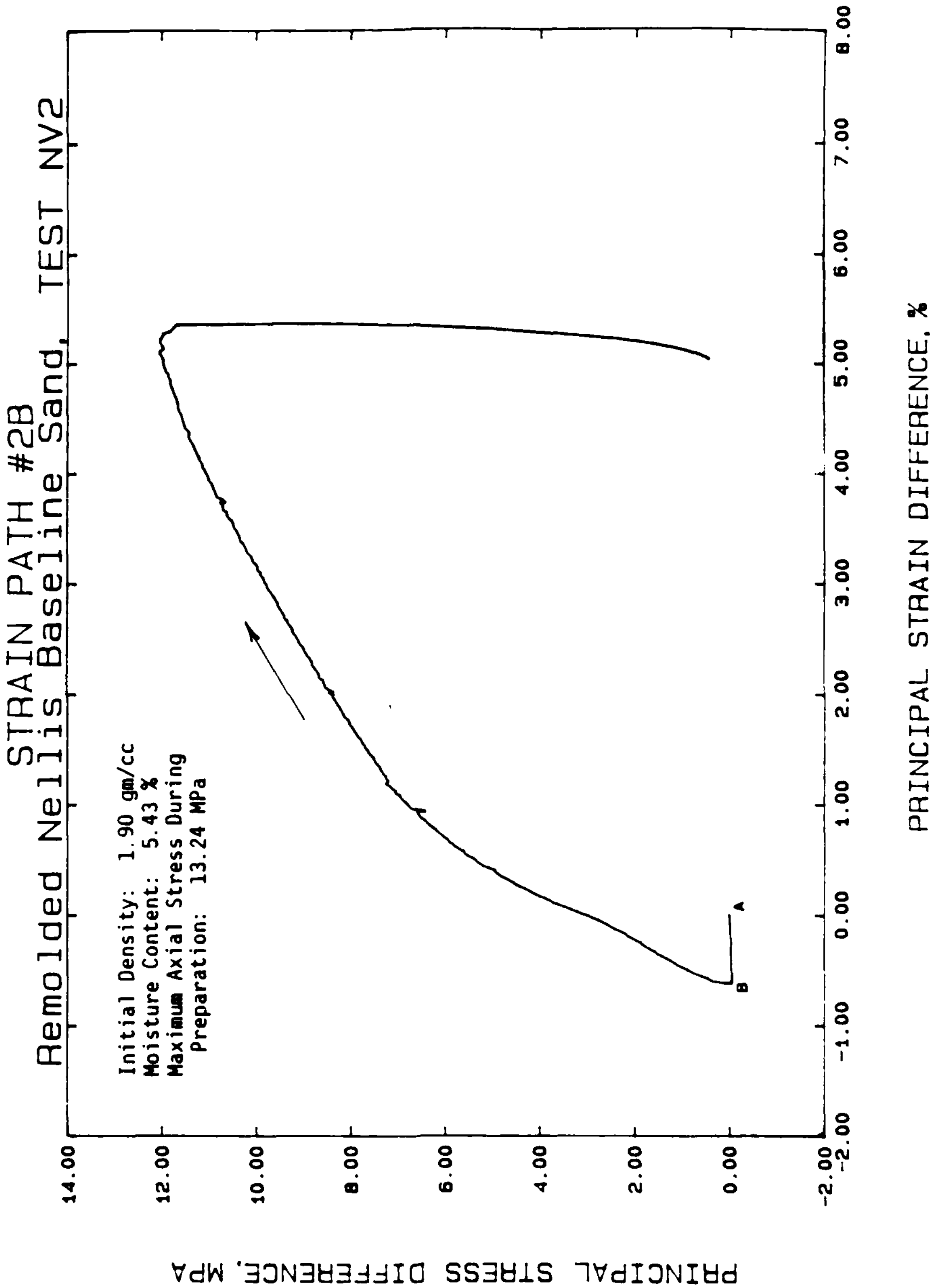
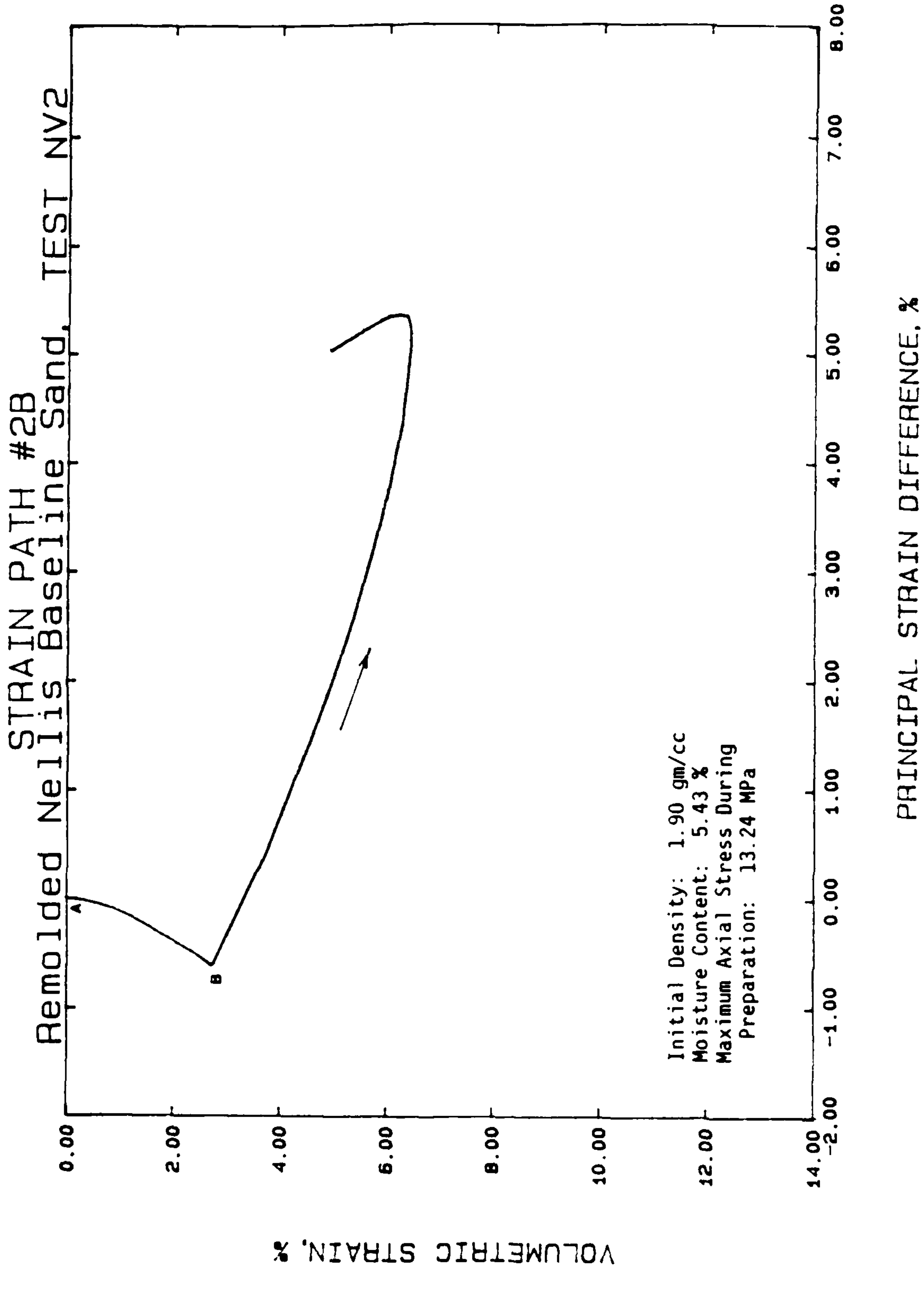

STRAIN PATH #2B
Remolded Nellis Baseline Sand. TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.43 %
Maximum Axial Stress During
Preparation: 13.24 MPa
A
B
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
PRINCIPAL STRESS DIFFERENCE, MPA
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
MEAN NORMAL STRESS, MPA

Plate 107



STRAIN PATH #2B
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.43 %
Maximum Axial Stress During
Preparation: 13.24 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-1.00
1.00
3.00
5.00
6.00
7.00
8.00

Plate 108



STRAIN PATH #2B
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.43 %
Maximum Axial Stress During
Preparation: 13.24 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

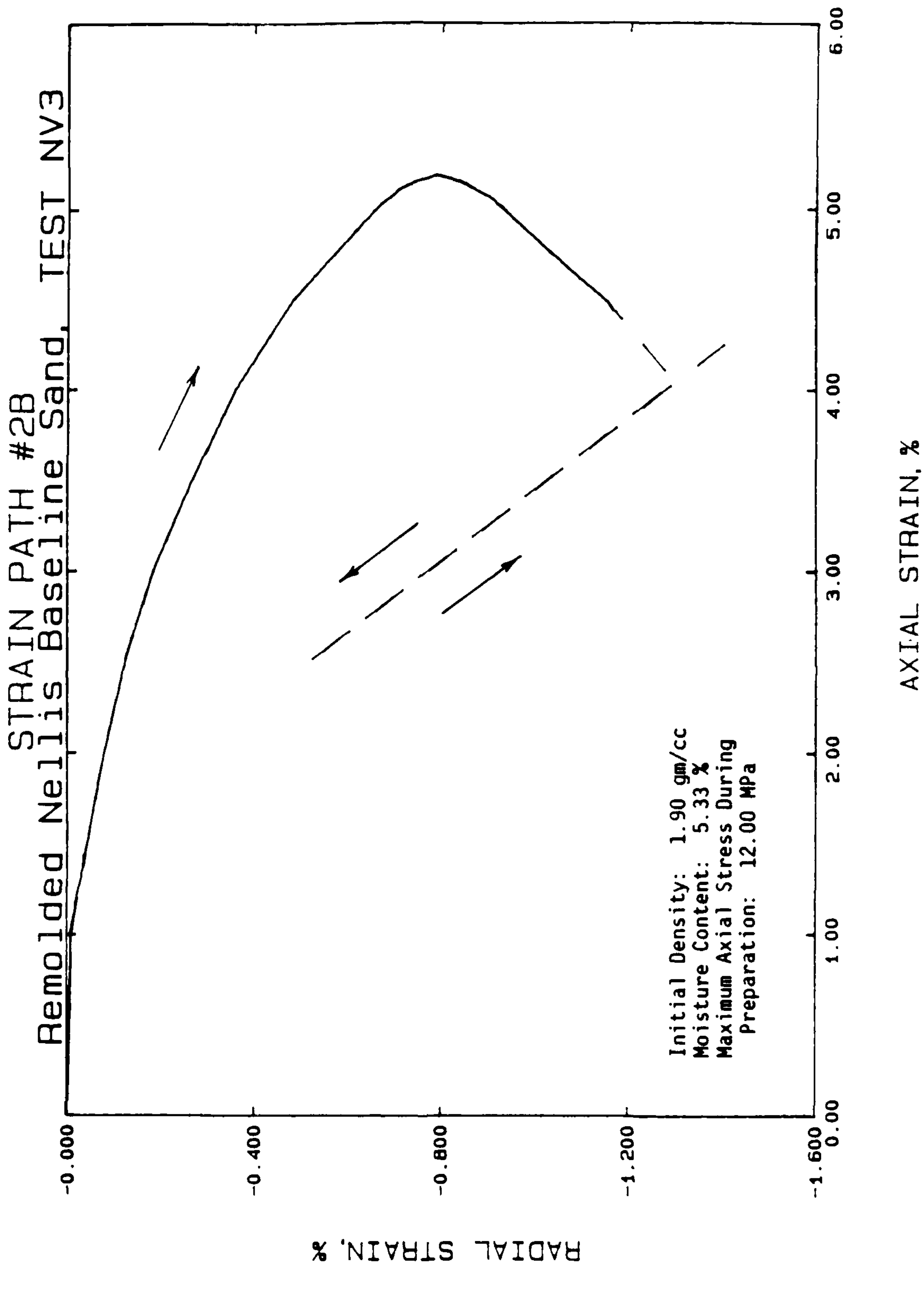
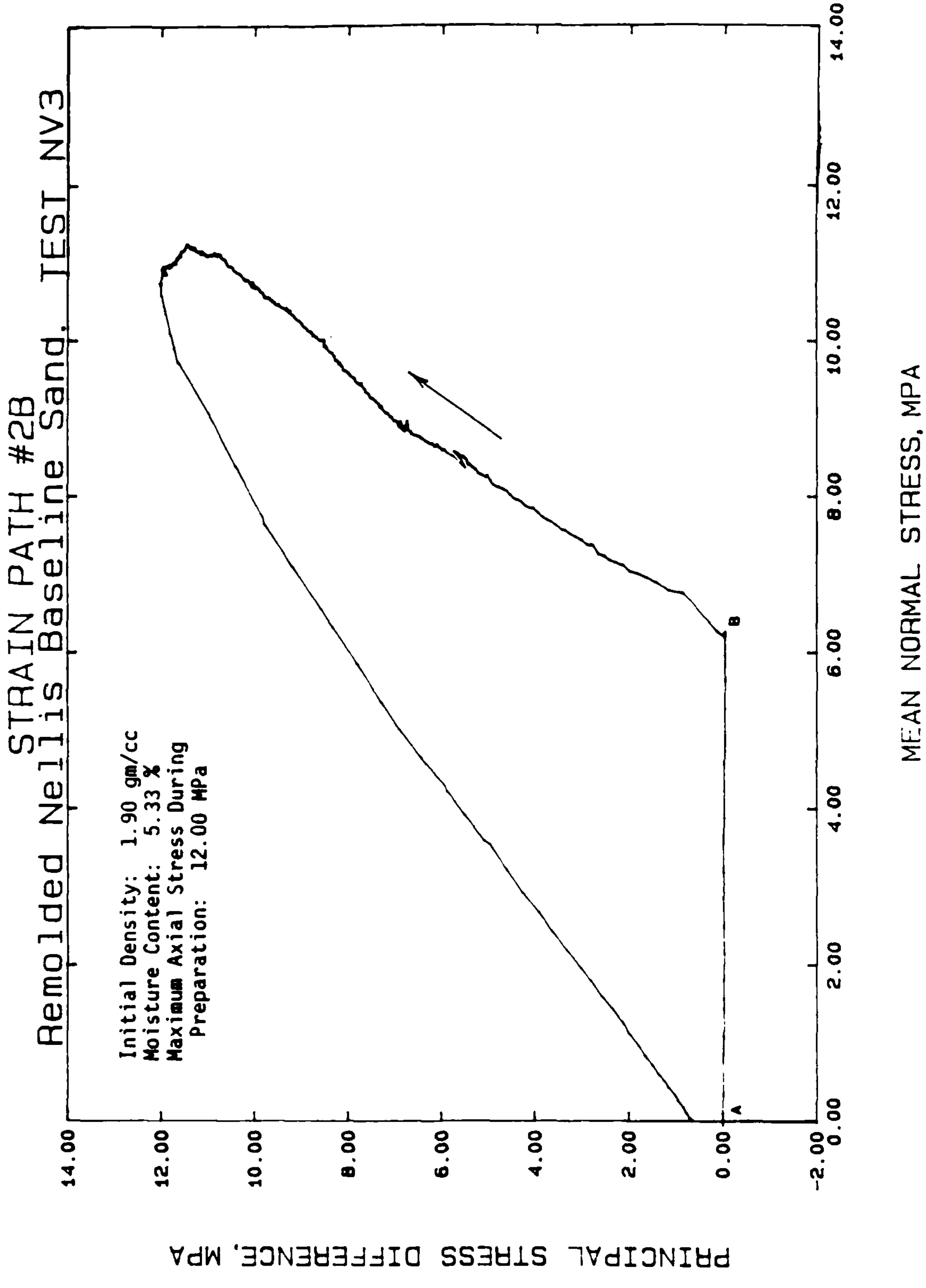

STRAIN PATH #2B
Remolded Nellis Baseline Sand, TEST NV3
Initial Density: 1.90 gm/cc
Moisture Content: 5.33 %
Maximum Axial Stress During
Preparation: 12.00 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
-0.000
-0.400
-0.800
-1.200
-1.600

Plate 110



STRAIN PATH #2B
Remoulded Nellis Baseline Sand. TEST NV3
Initial Density: 1.90 gm/cc
Moisture Content: 5.33 %
Maximum Axial Stress During
Preparation: 12.00 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 111

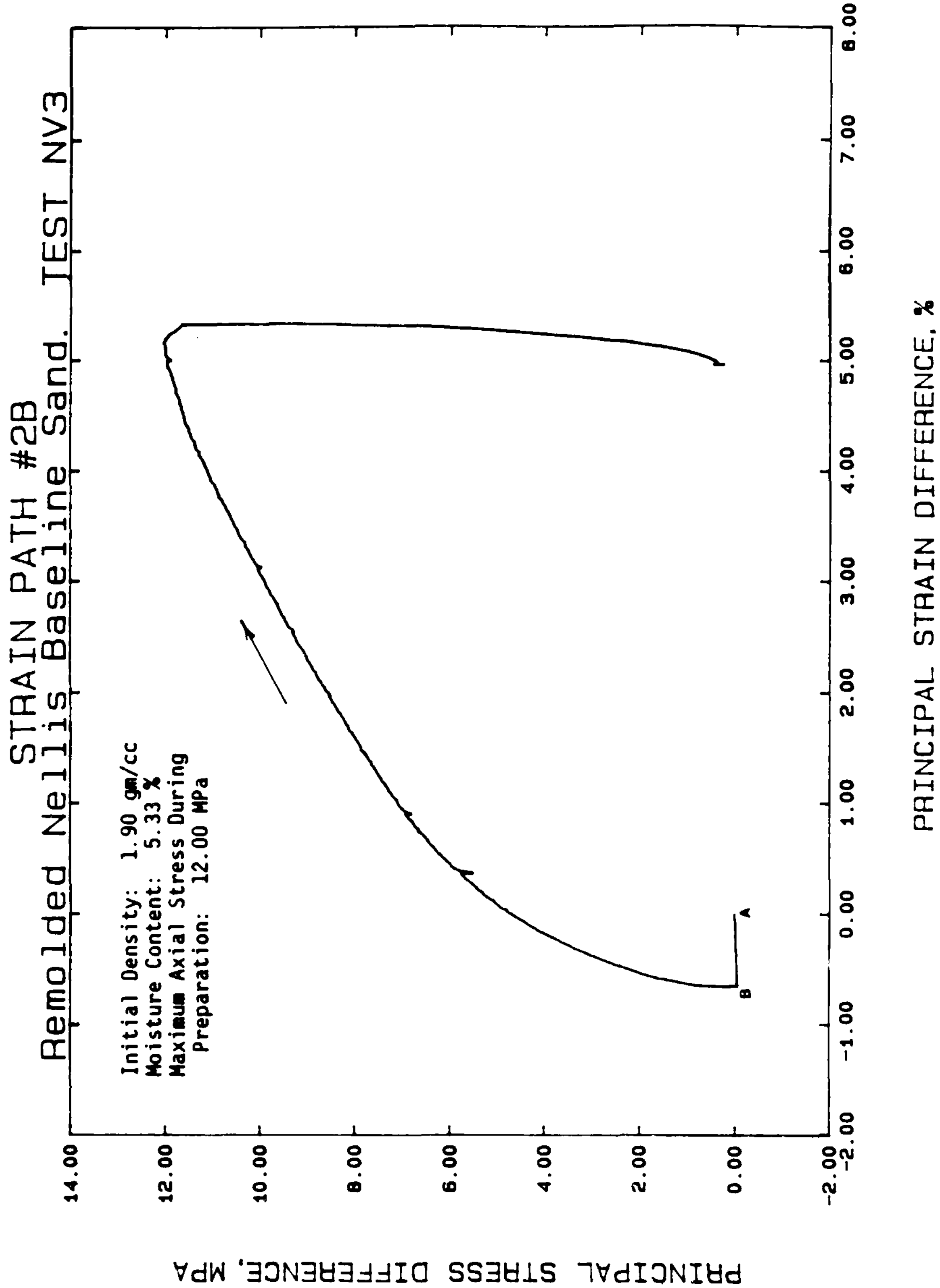
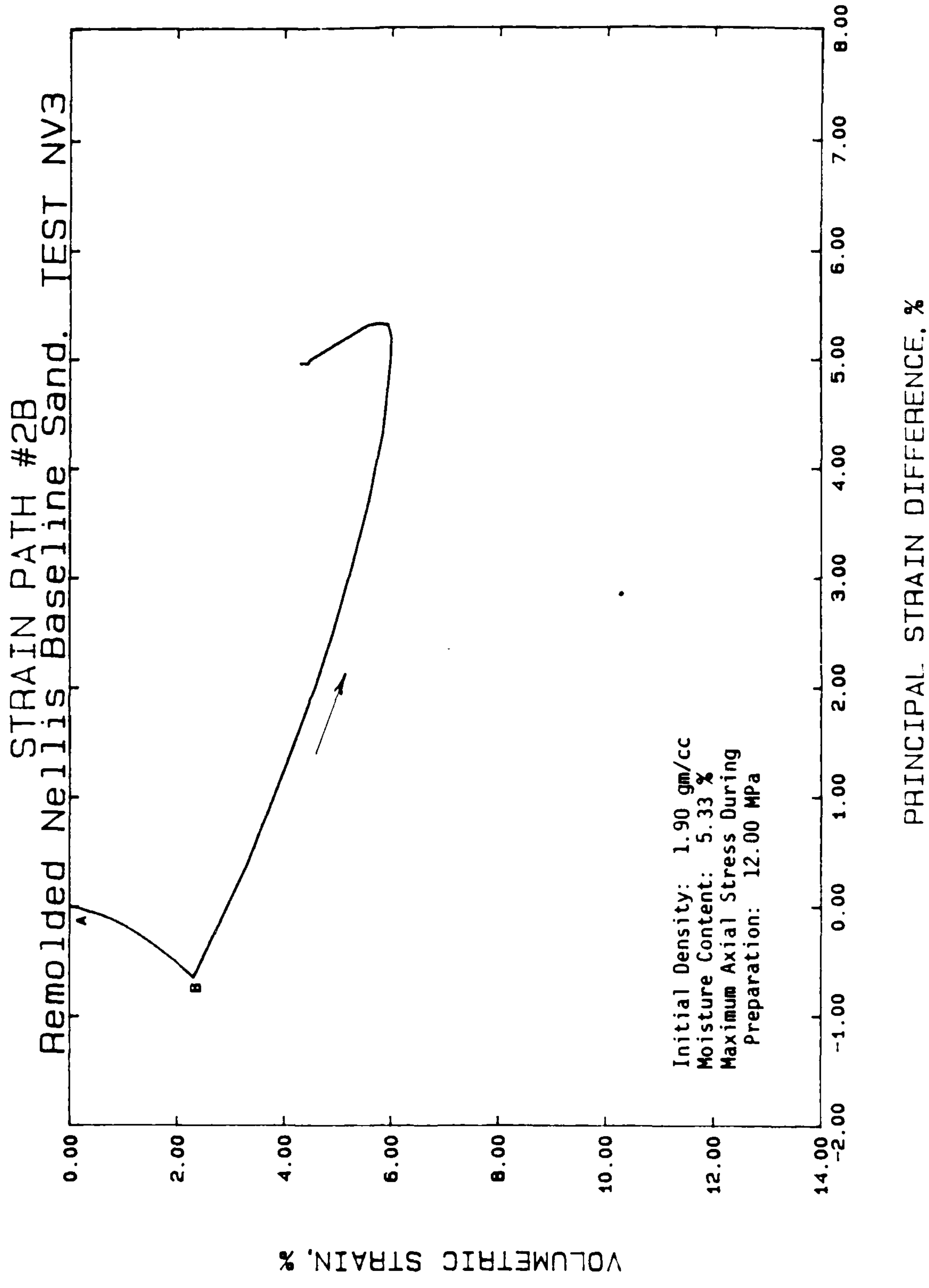
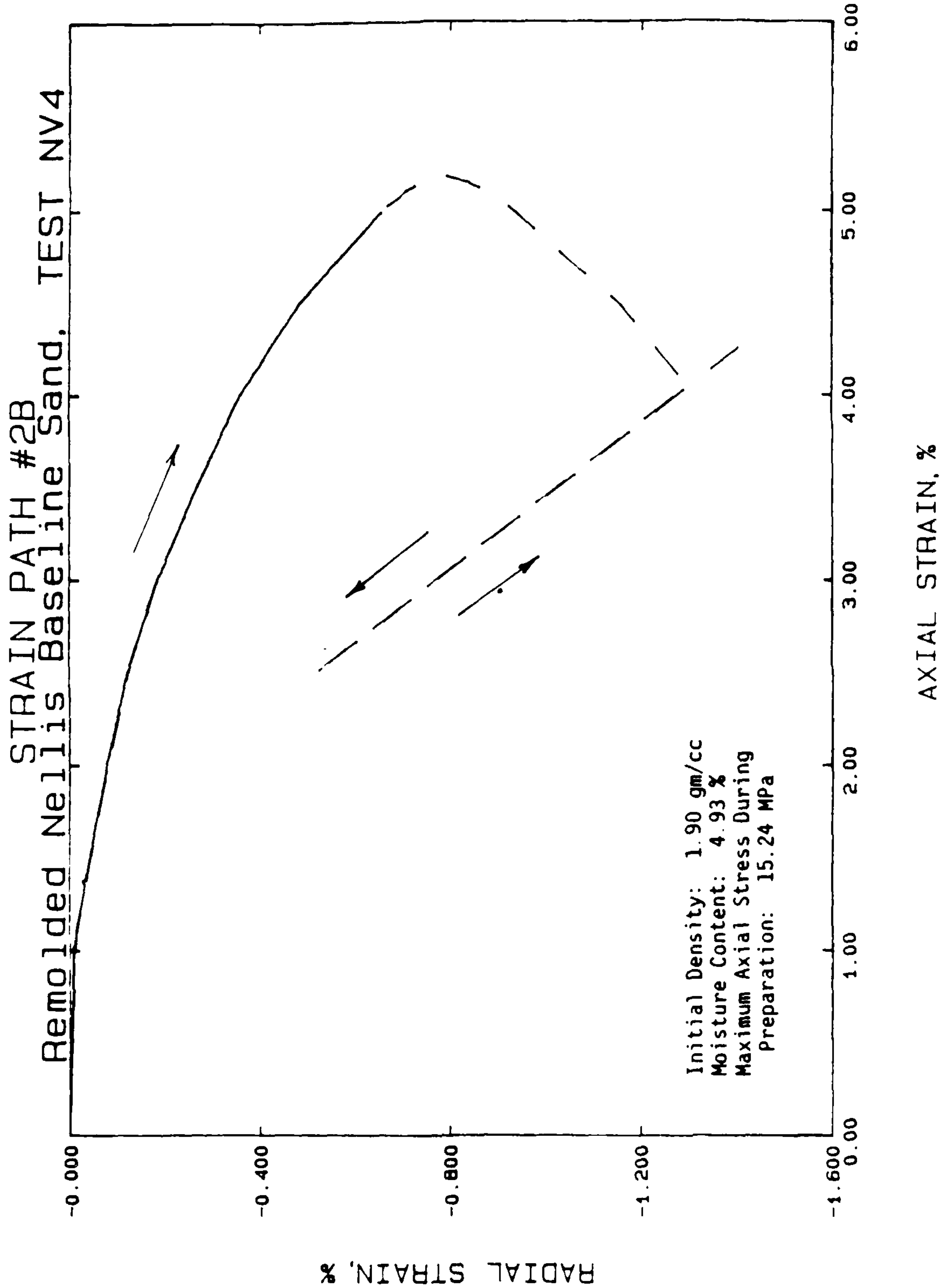

STRAIN PATH #2B
Remolded Nellis Baseline Sand. TEST NV3
Initial Density: 1.90 gm/cc
Moisture Content: 5.33 %
Maximum Axial Stress During
Preparation: 12.00 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00

Plate 112


STRAIN PATH #2B
Remolded Nellis Baseline Sand. TEST NV3
Initial Density: 1.90 gm/cc
Moisture Content: 5.33 %
Maximum Axial Stress During
Preparation: 12.00 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00


STRAIN PATH #2B
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 4.93 %
Maximum Axial Stress During
Preparation: 15.24 MPa
-0.000
-0.400
-0.800
-1.200
-1.600
0.00
1.00
2.00
3.00
4.00
5.00
6.00
RADIAL STRAIN, %
AXIAL STRAIN, %

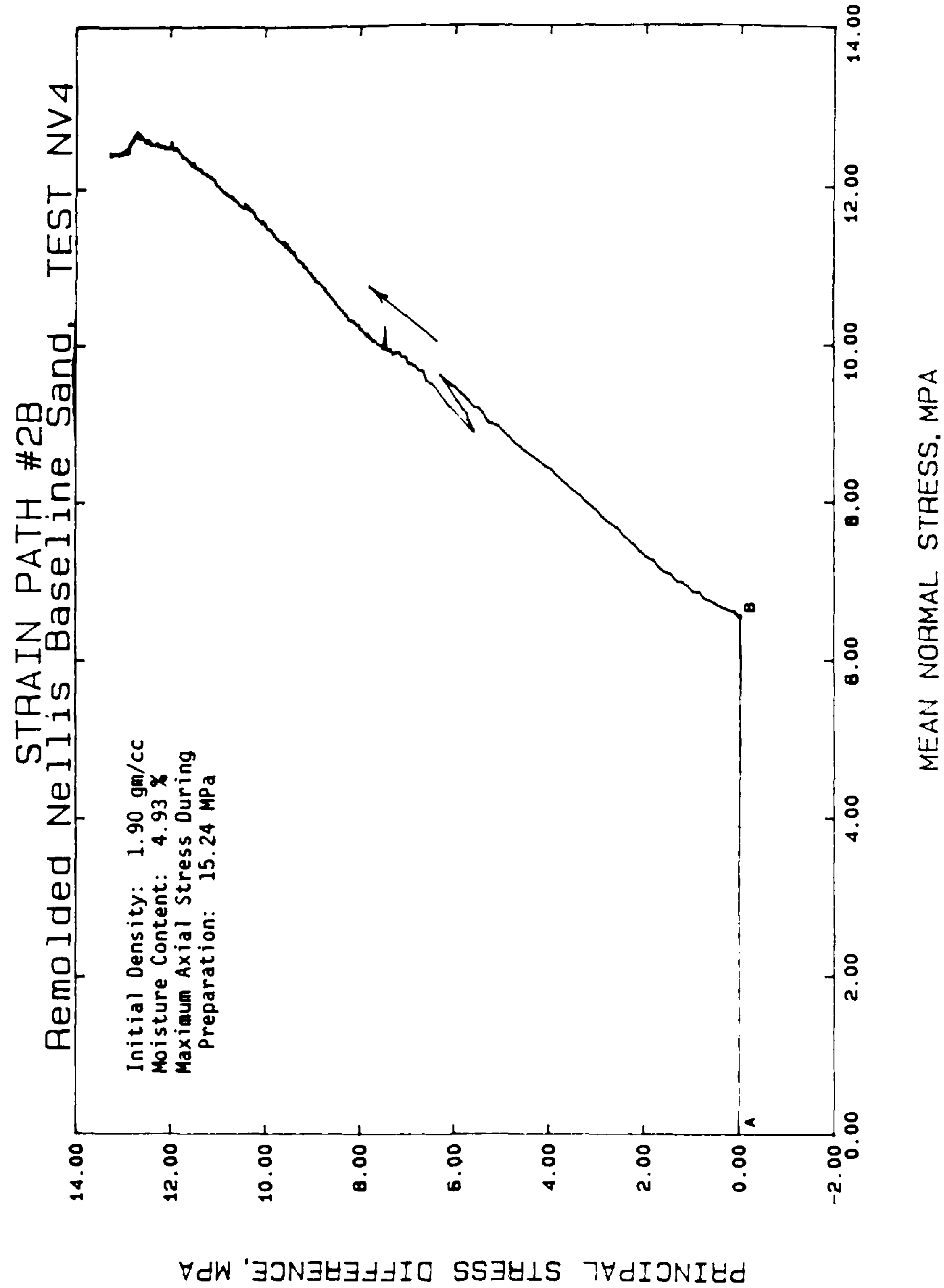

STRAIN PATH #2B
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 4.93 %
Maximum Axial Stress During
Preparation: 15.24 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
A
B

Plate 115

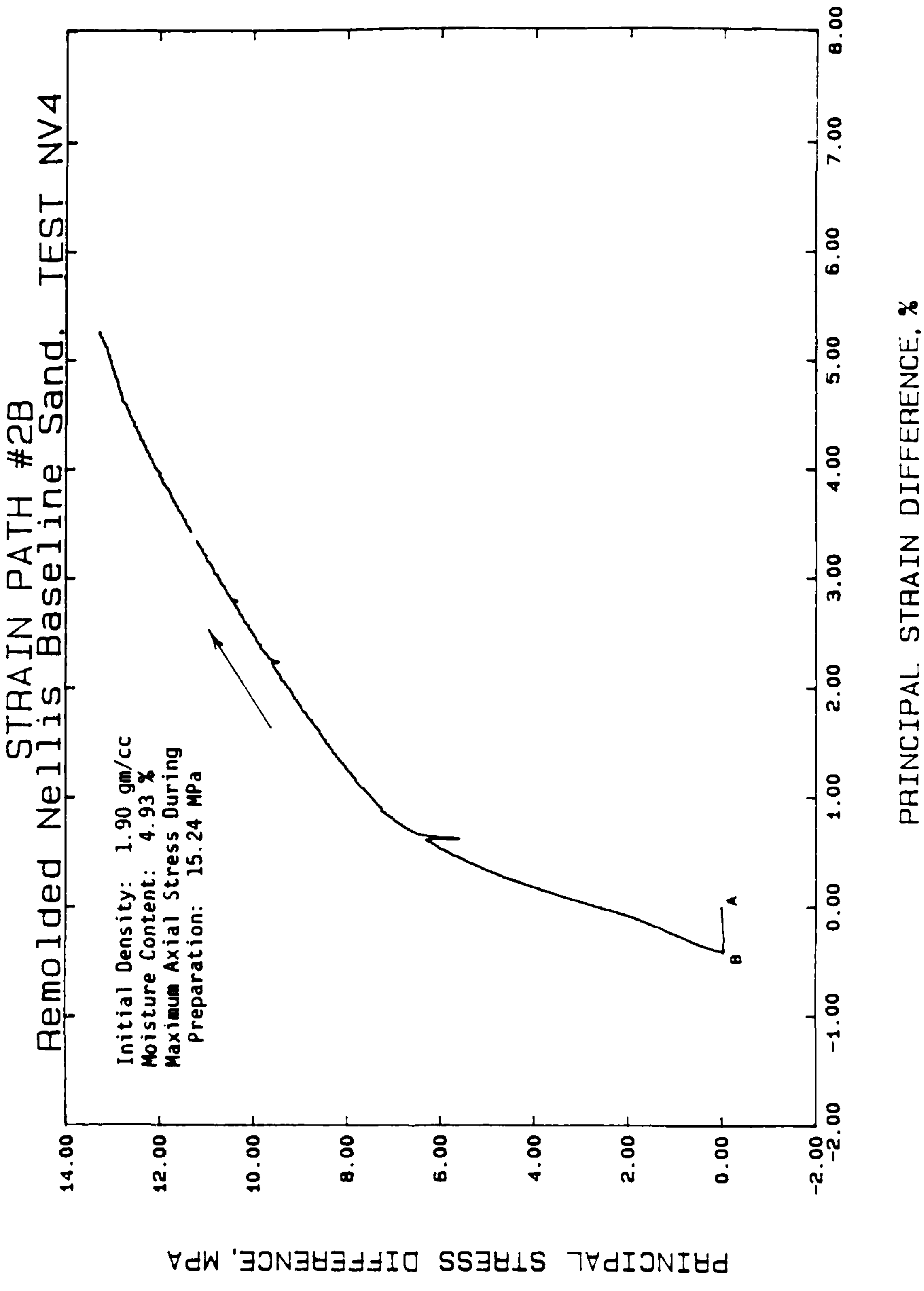

STRAIN PATH #2B
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 4.93 %
Maximum Axial Stress During
Preparation: 15.24 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 116

STRAIN PATH #2B
Remolded Nellis Baseline Sand. TEST NV4

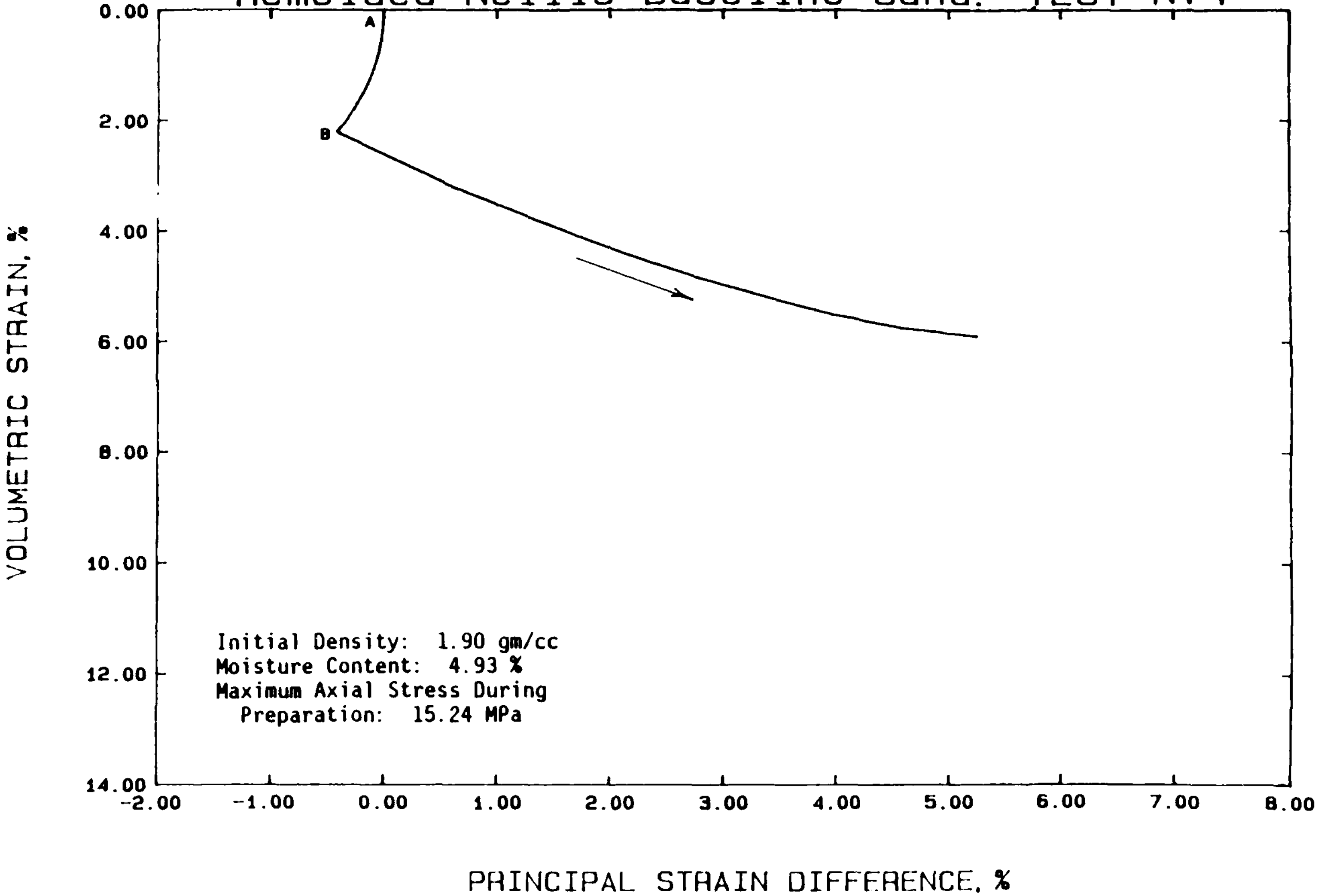
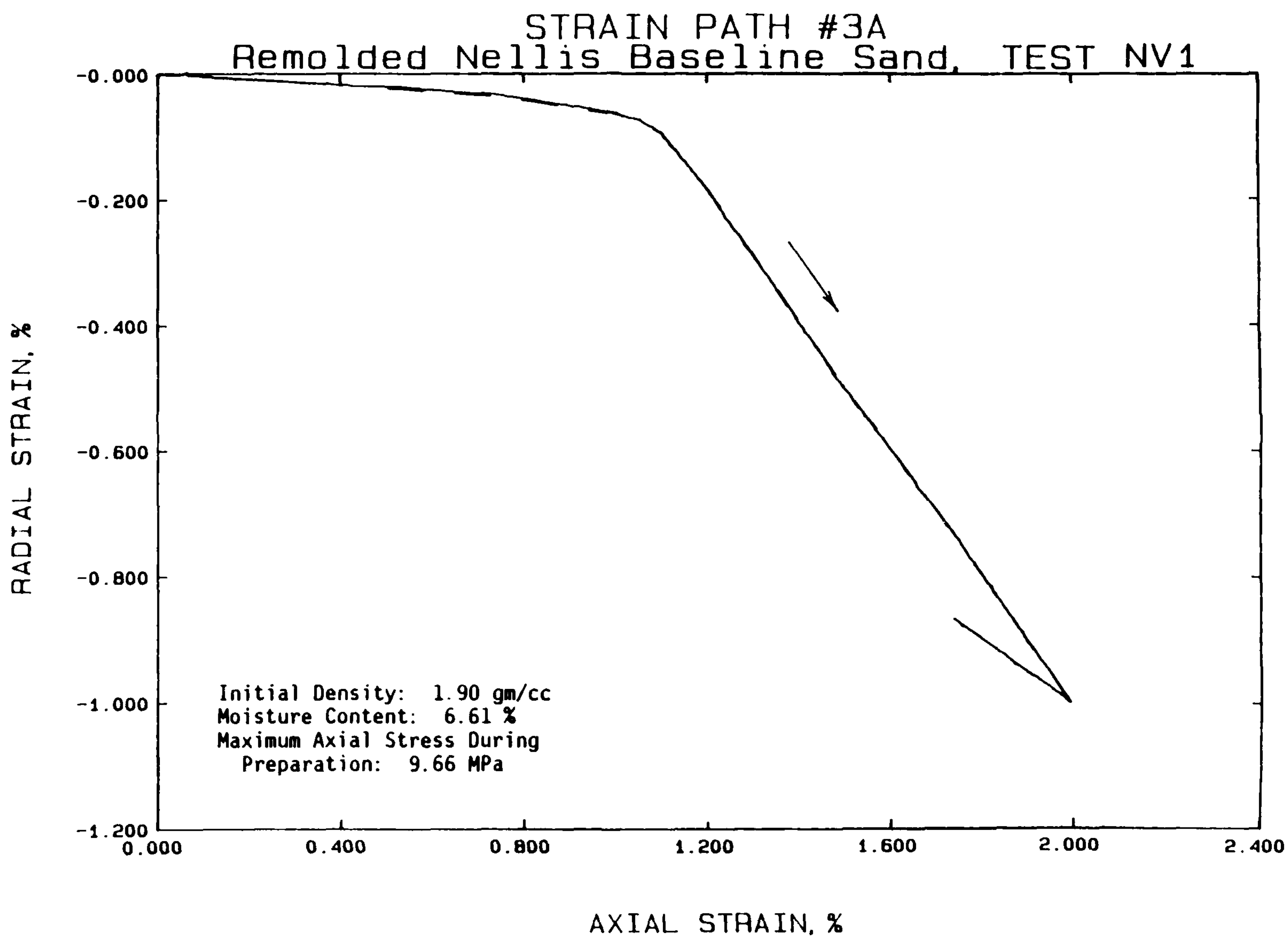
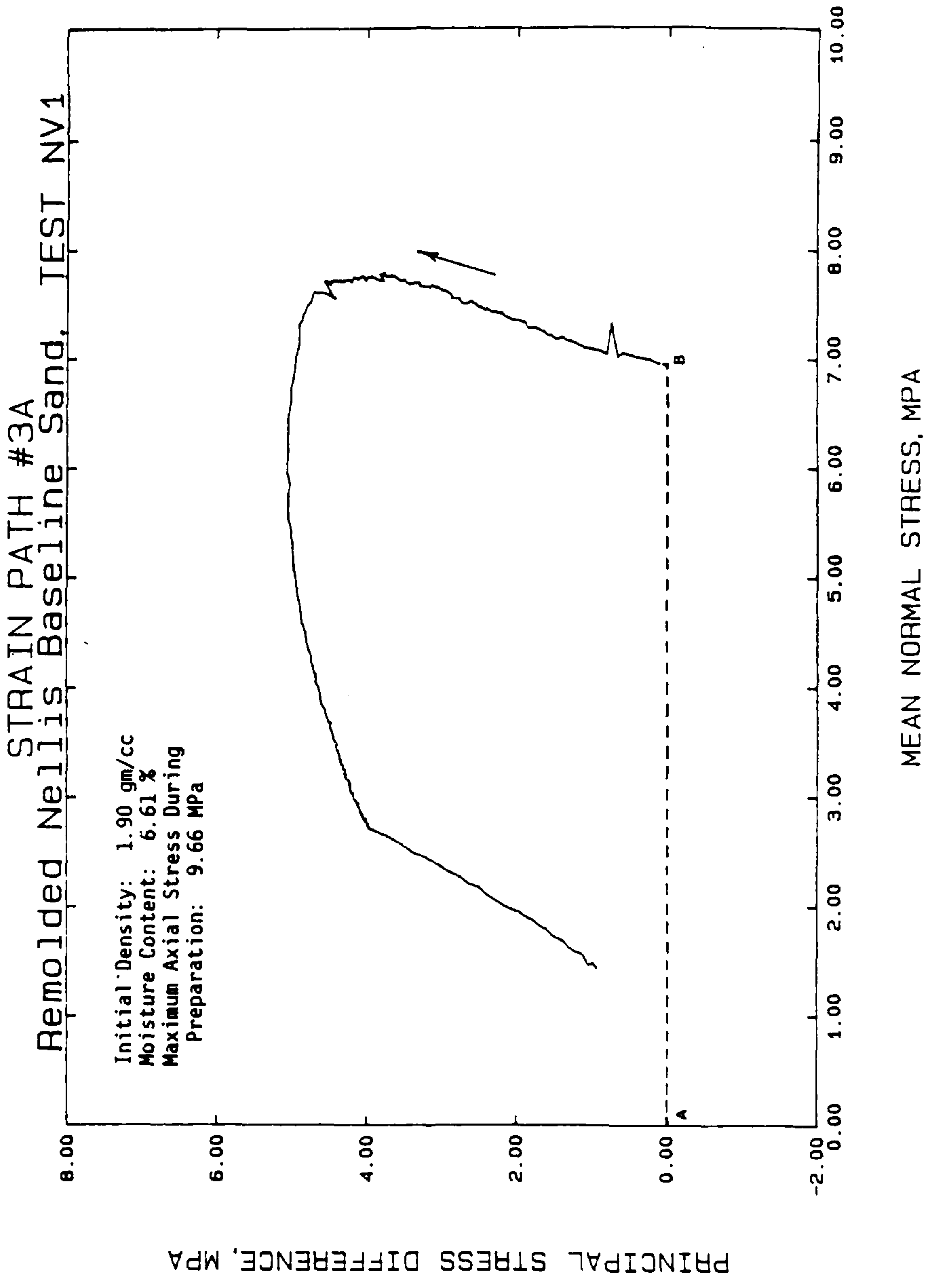


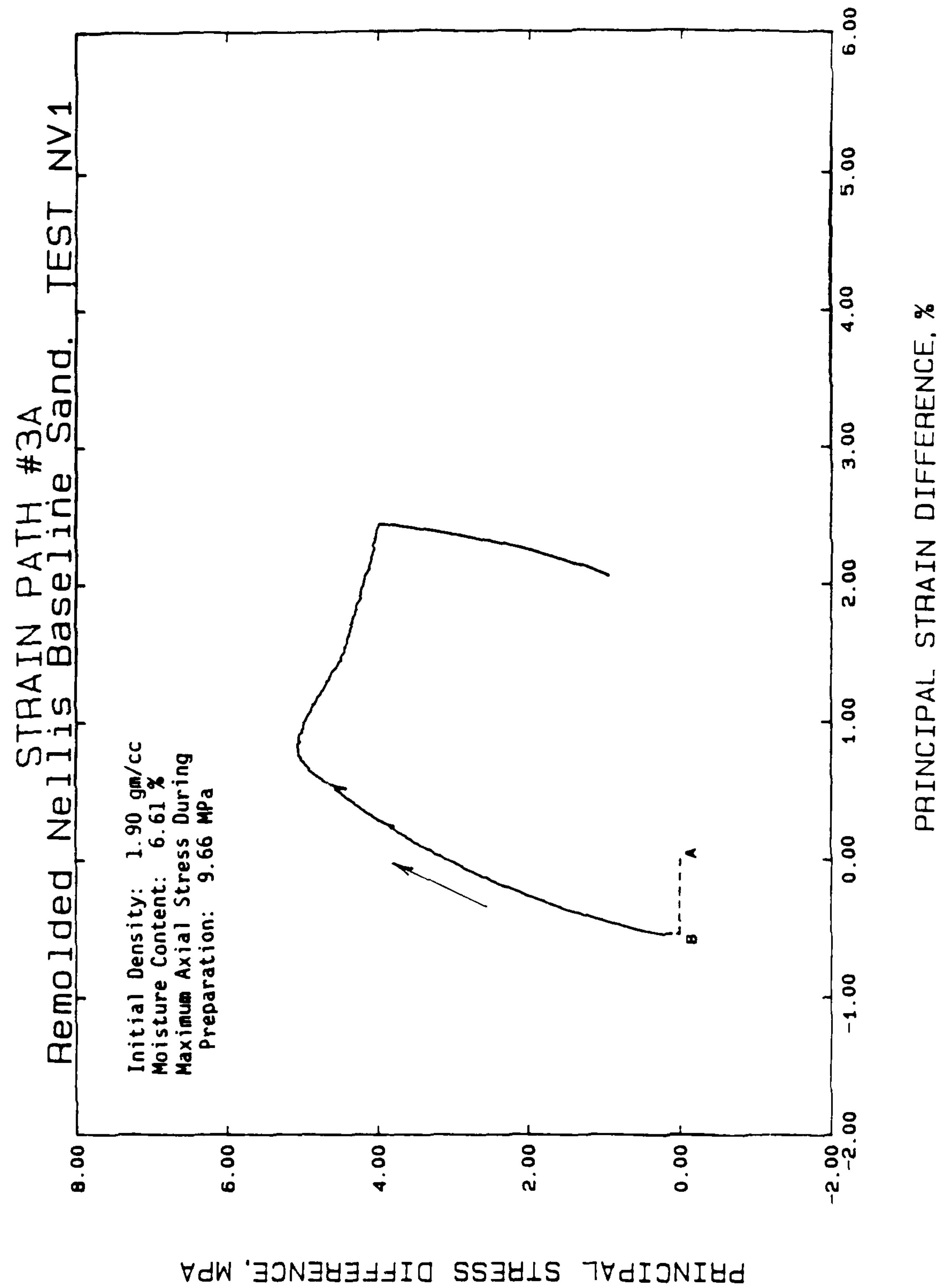
Plate 117



STRAIN PATH #3A
Remolded Nellis Baseline Sand, TEST NV1
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
AXIAL STRAIN, %
Initial Density: 1.90 gm/cc
Moisture Content: 6.61 %
Maximum Axial Stress During
Preparation: 9.66 MPa

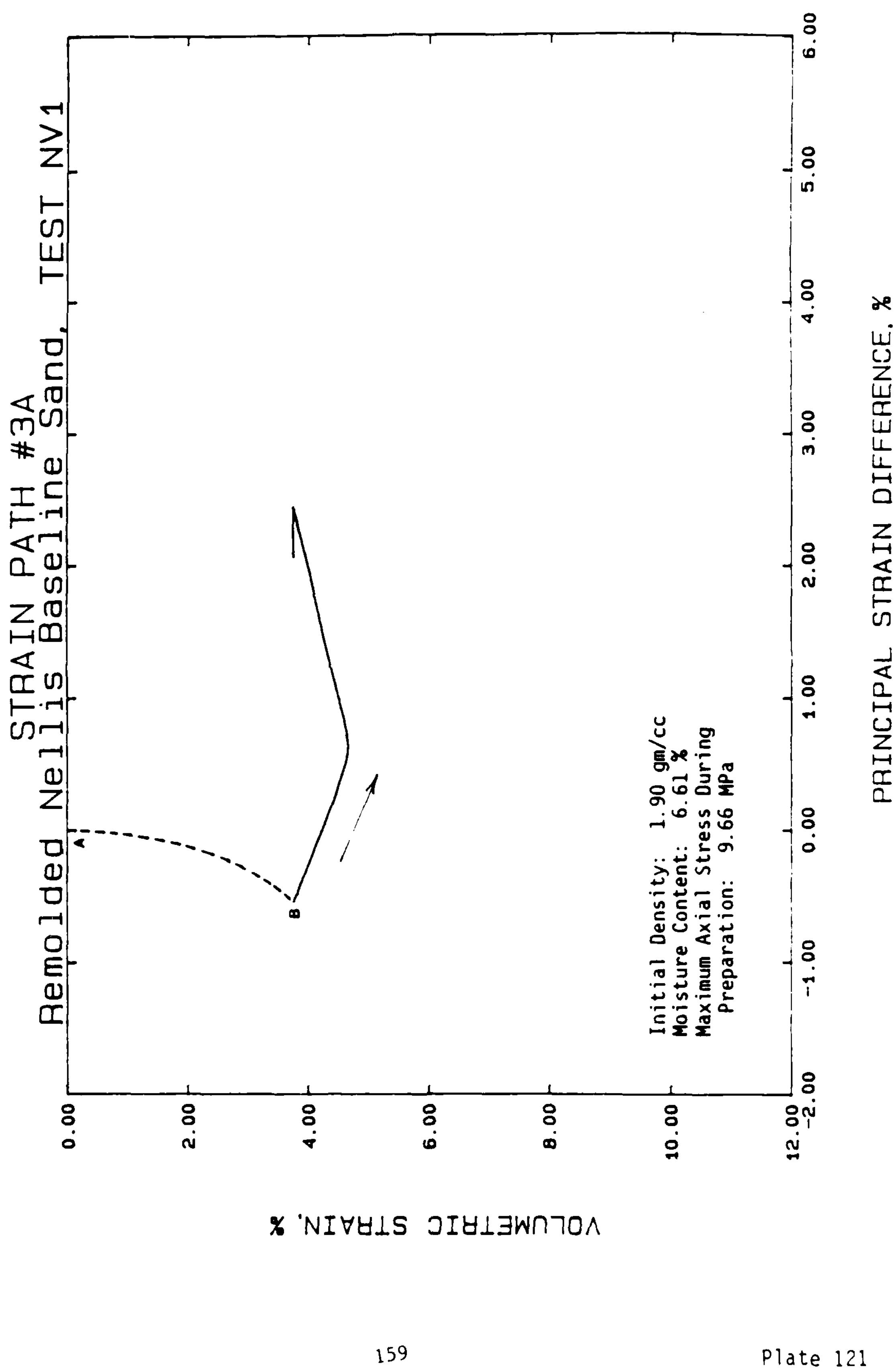
Plate 118

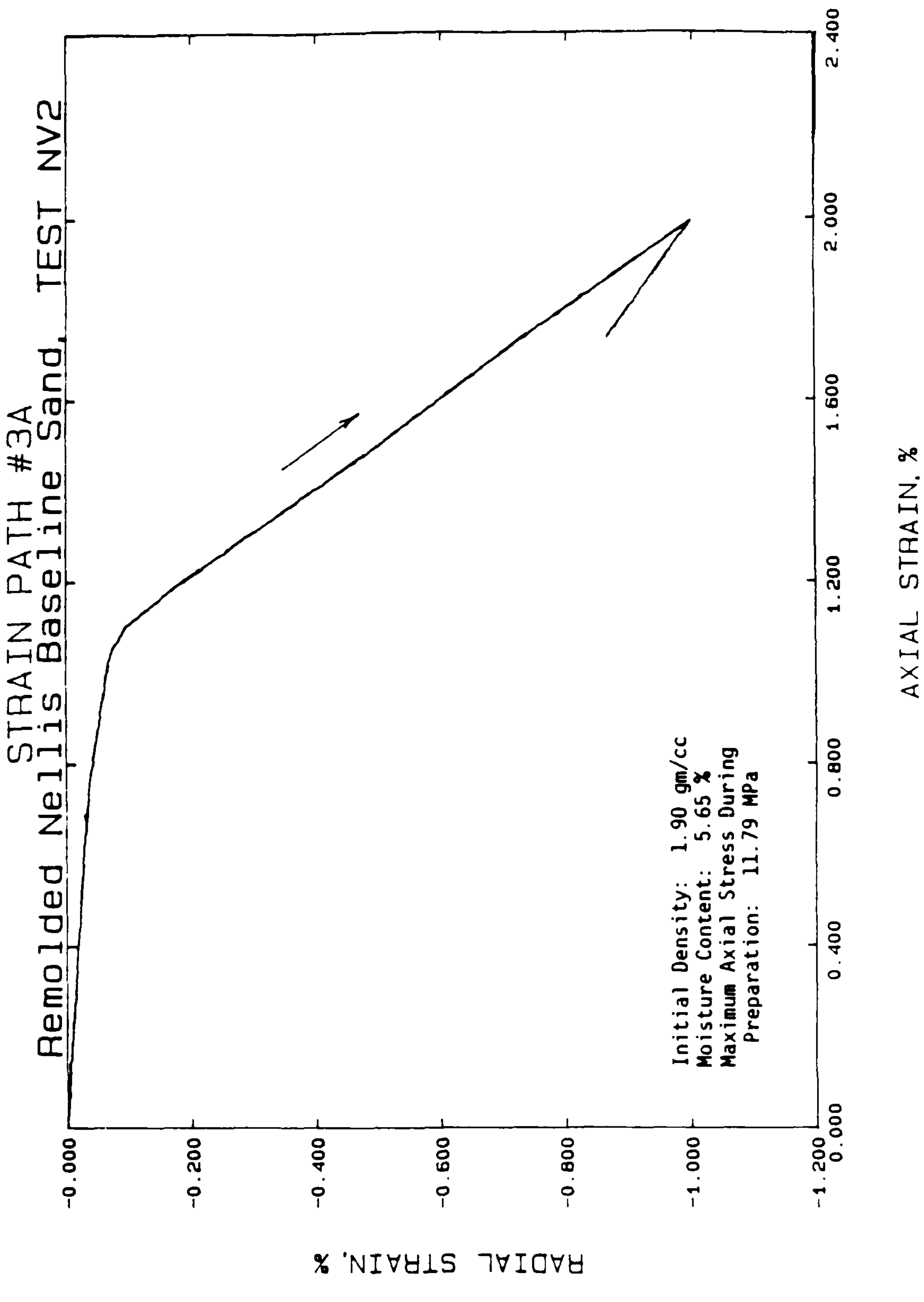

STRAIN PATH #3A
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.90 gm/cc
Moisture Content: 6.61 %
Maximum Axial Stress During
Preparation: 9.66 MPa
A
B
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
MEAN NORMAL STRESS, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
PRINCIPAL STRESS DIFFERENCE, MPA

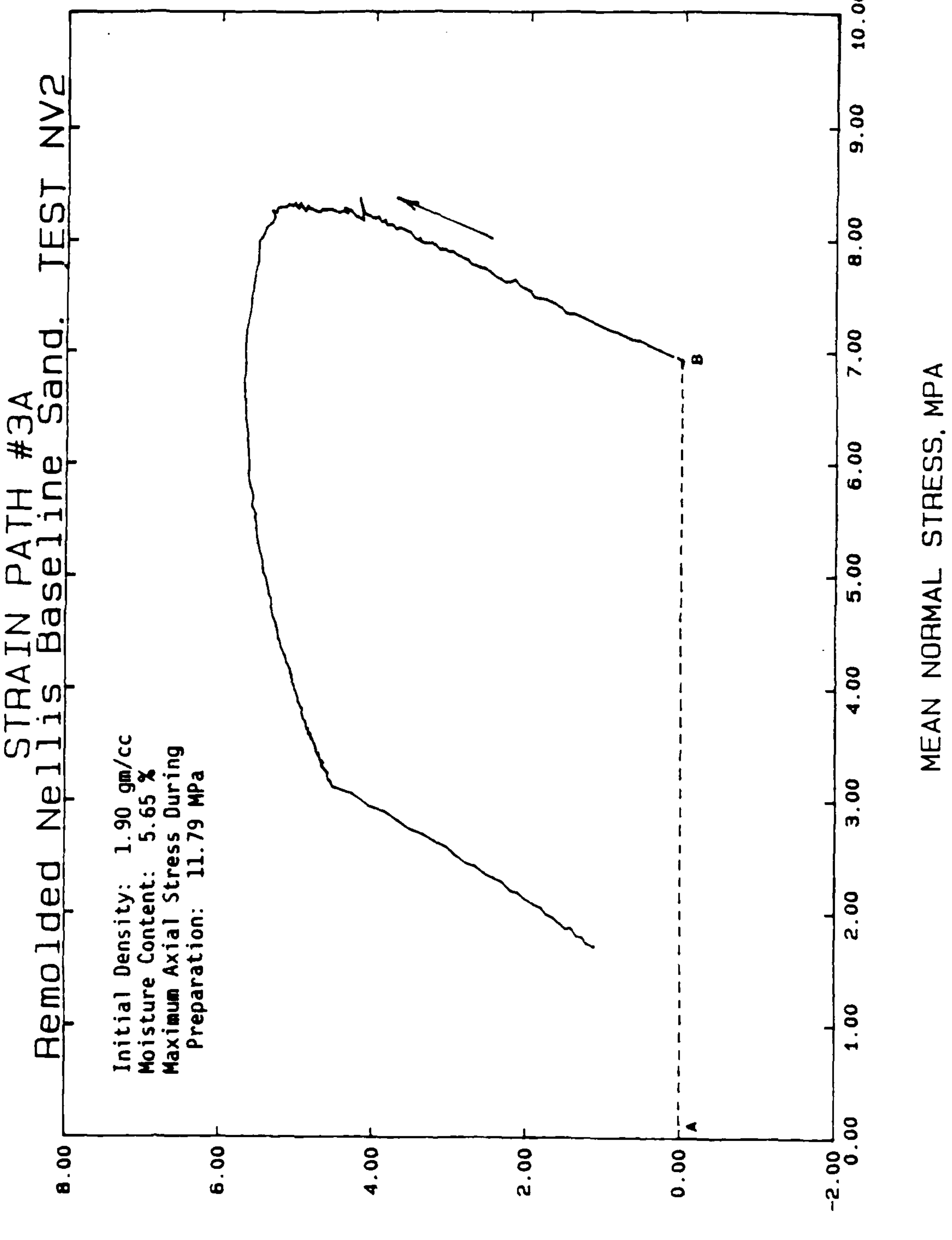


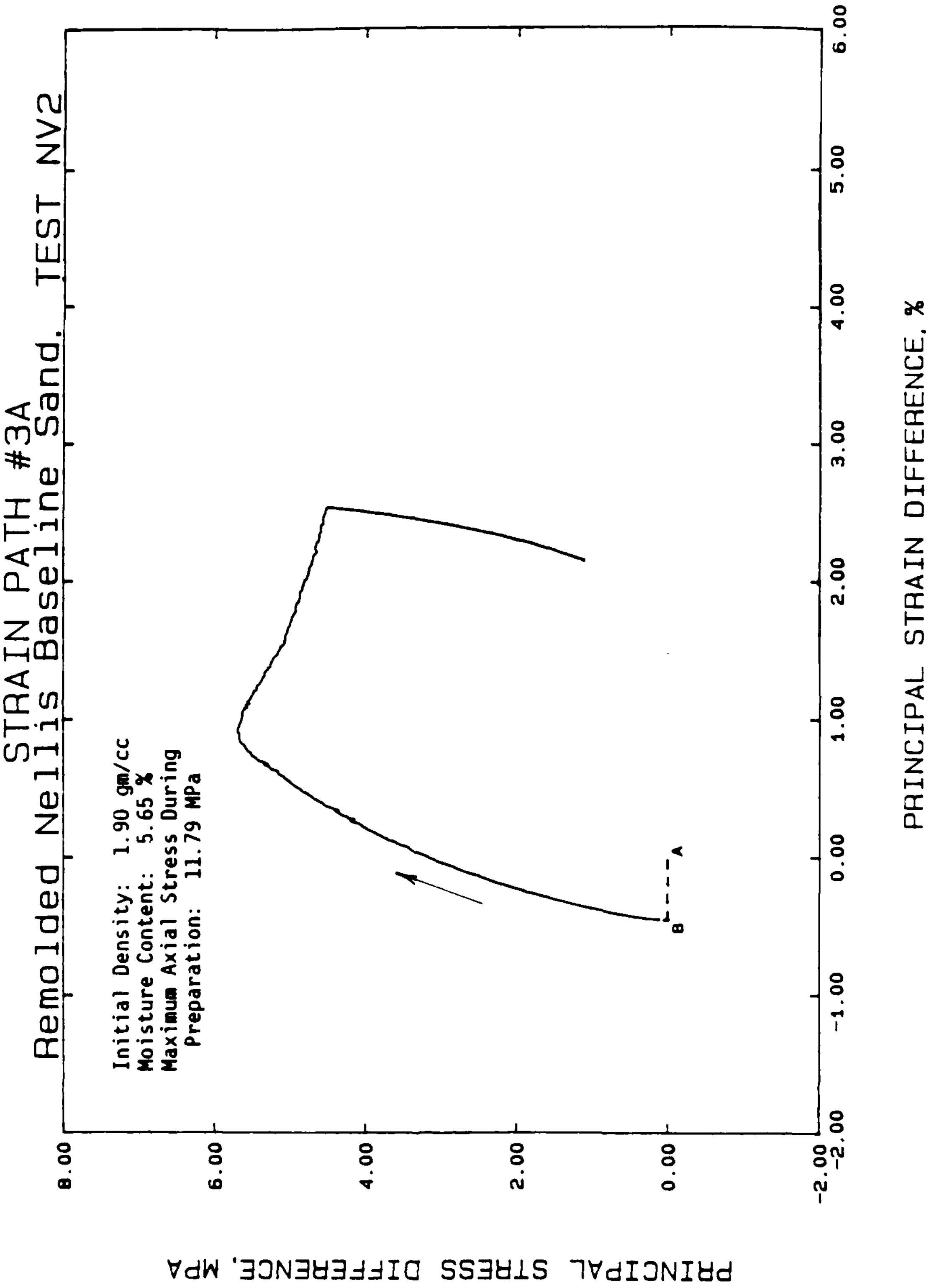
STRAIN PATH #3A
Remolded Nellis Baseline Sand. TEST NV1
Initial Density: 1.90 gm/cc
Moisture Content: 6.61 %
Maximum Axial Stress During
Preparation: 9.66 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %

Plate 120


STRAIN PATH #3A
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.90 gm/cc
Moisture Content: 6.61 %
Maximum Axial Stress During
Preparation: 9.66 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00

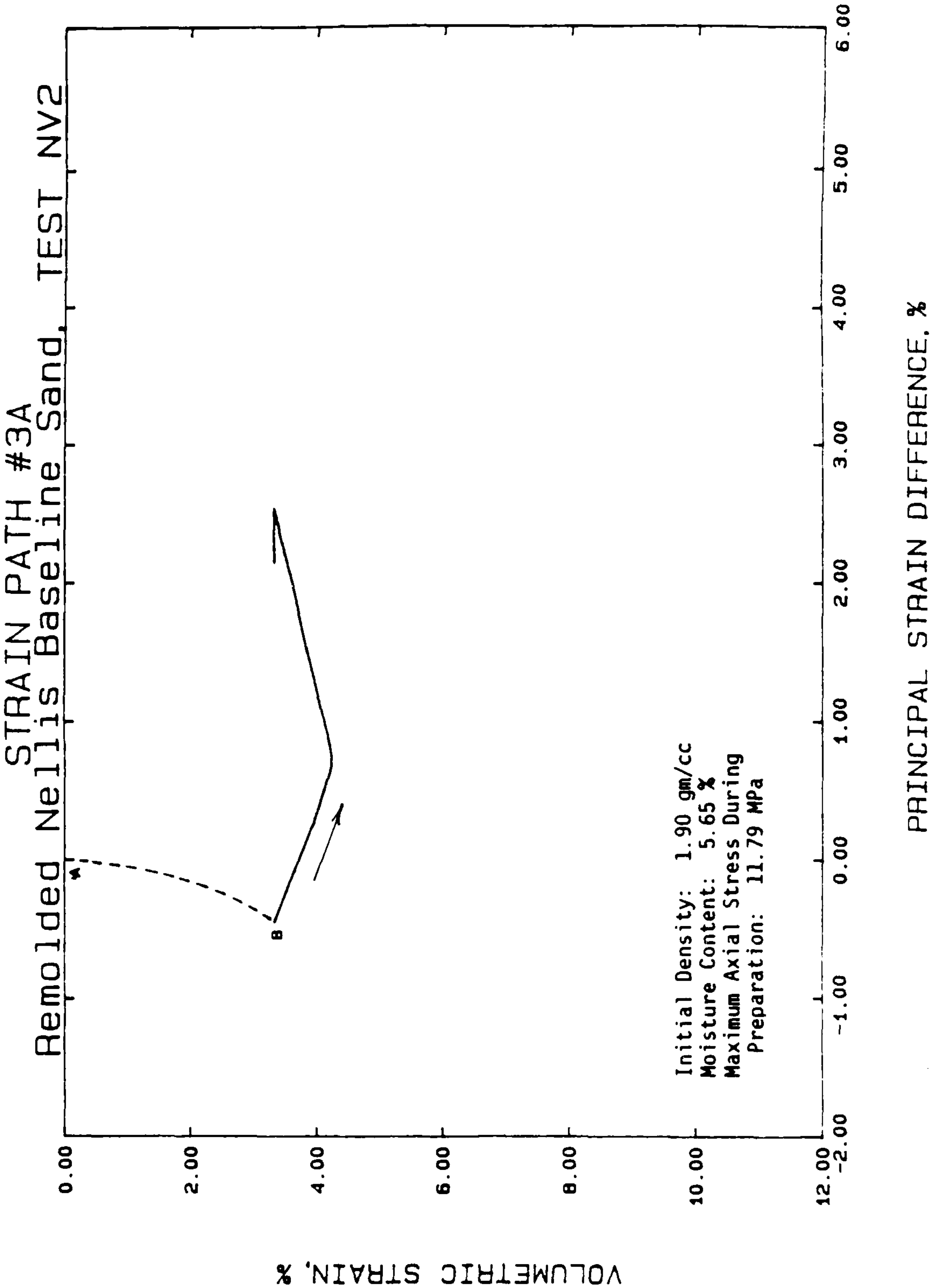

STRAIN PATH #3A
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.65 %
Maximum Axial Stress During
Preparation: 11.79 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200


STRAIN PATH #3A
Remolded Nellis Baseline Sand. TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.65 %
Maximum Axial Stress During
Preparation: 11.79 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00



STRAIN PATH #3A
Remolded Nellis Baseline Sand. TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.65 %
Maximum Axial Stress During Preparation: 11.79 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
8.00

Plate 124


STRAIN PATH #3A
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 5.65 %
Maximum Axial Stress During
Preparation: 11.79 MPa
A
B
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
VOLUMETRIC STRAIN, %

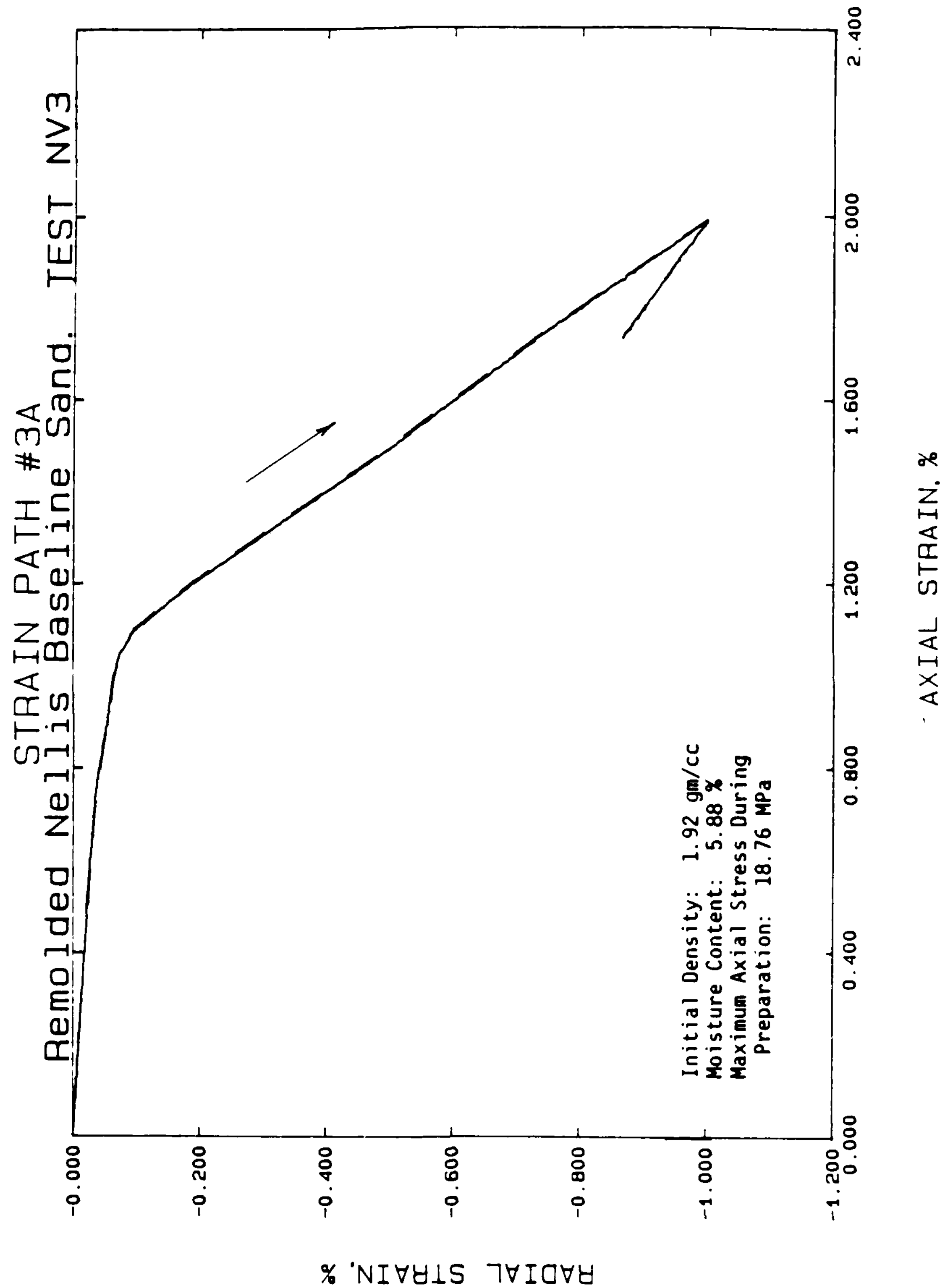

STRAIN PATH #3A
Remolded Nellis Baseline Sand, TEST NV3
Initial Density: 1.92 gm/cc
Moisture Content: 5.88 %
Maximum Axial Stress During
Preparation: 18.76 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200

Plate 126

STRAIN PATH #3A

Remolded Nellis Baseline Sand, TEST NV3

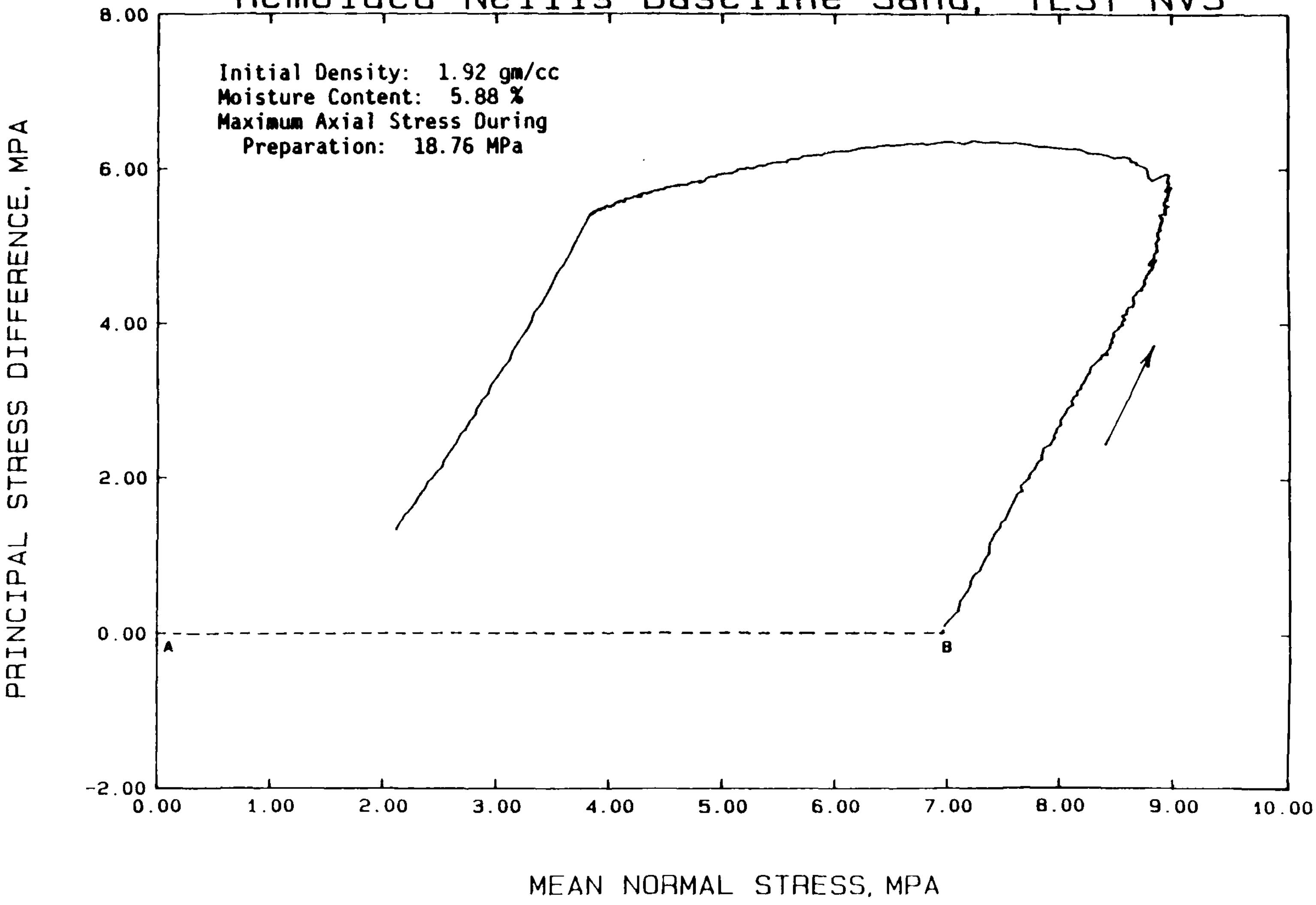


Plate 127

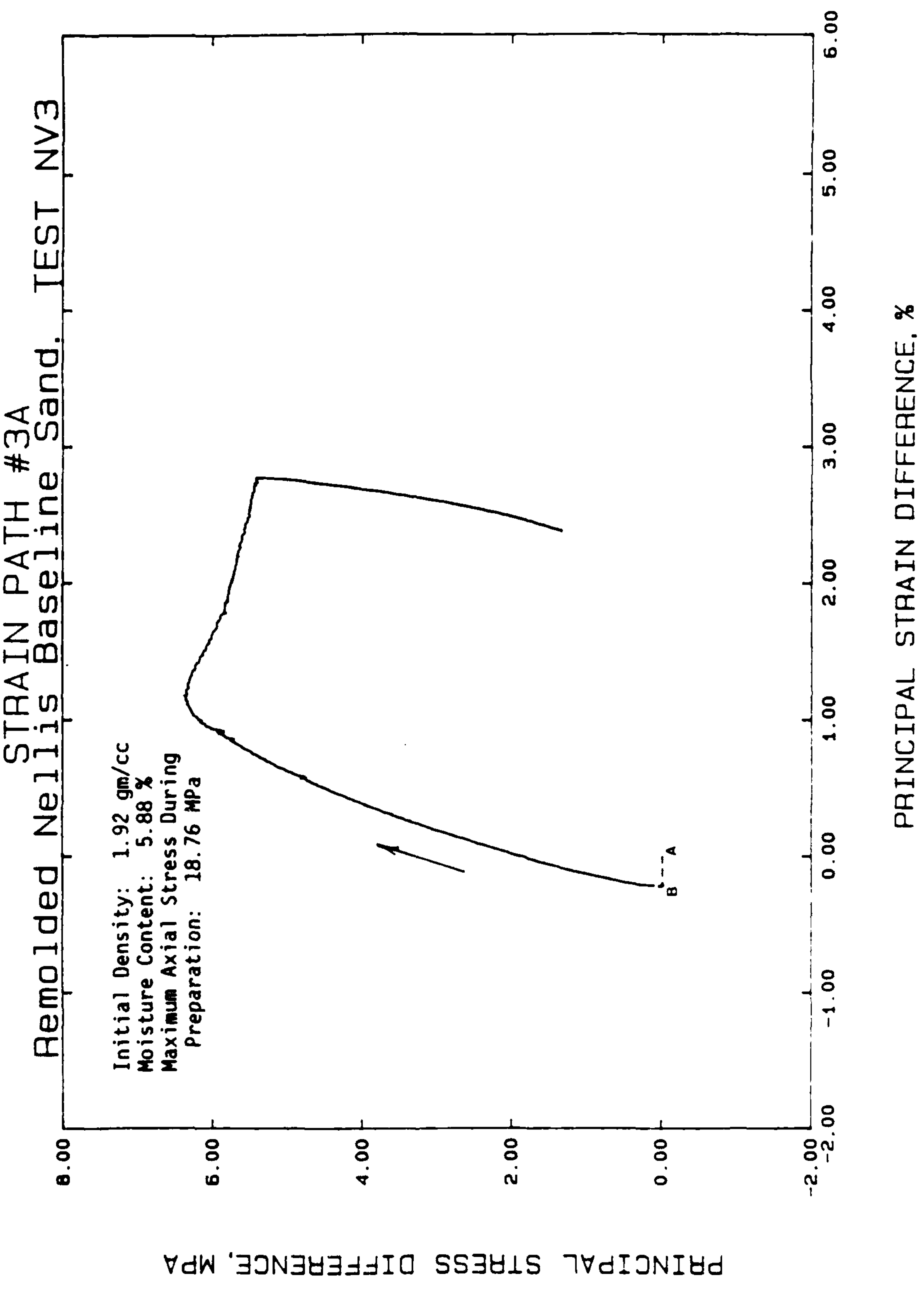
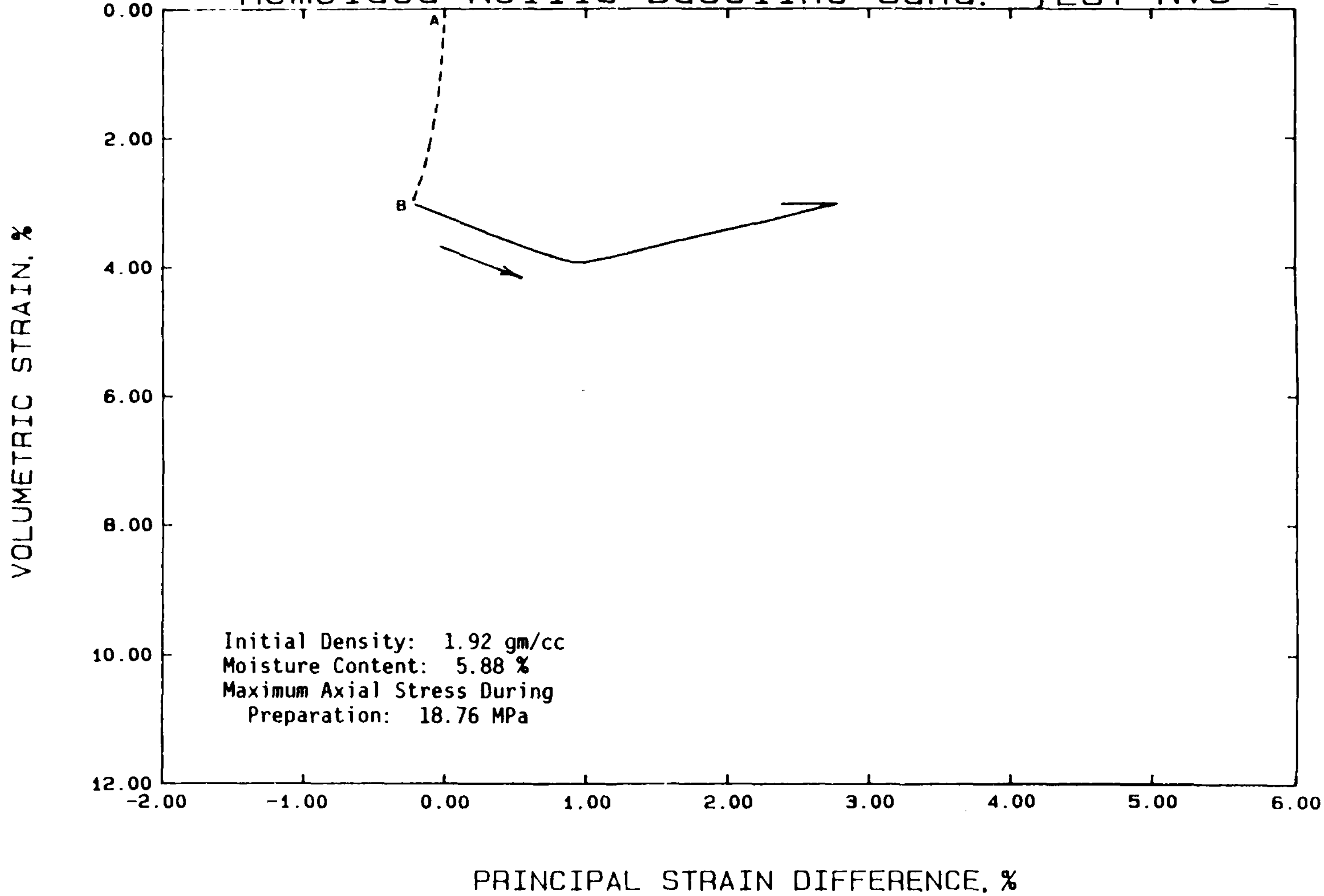

STRAIN PATH #3A
Remolded Nellis Baseline Sand. TEST NV3
Initial Density: 1.92 gm/cc
Moisture Content: 5.88 %
Maximum Axial Stress During
Preparation: 18.76 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00

Plate 128

STRAIN PATH #3A
Remolded Nellis Baseline Sand. TEST NV3



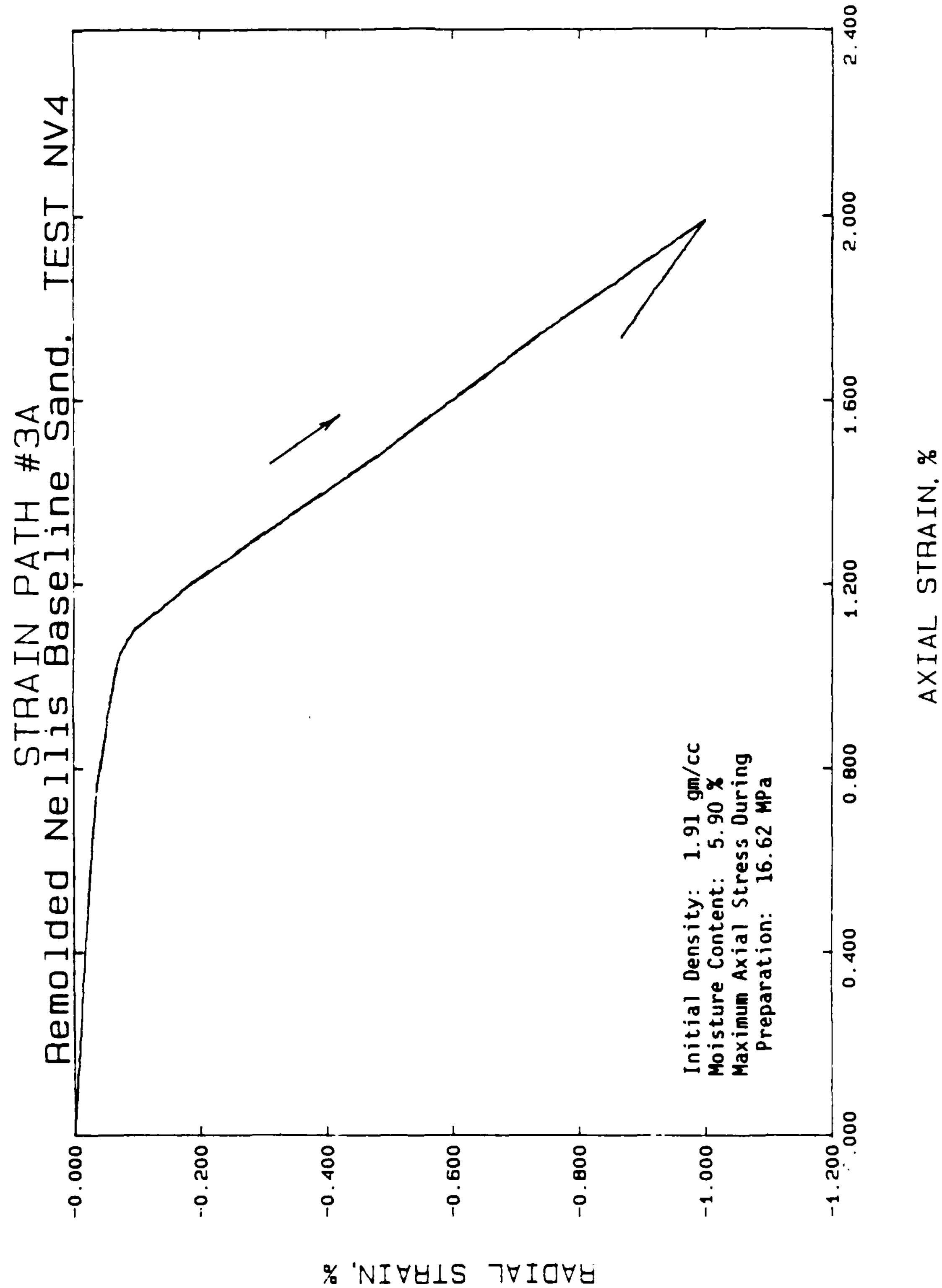
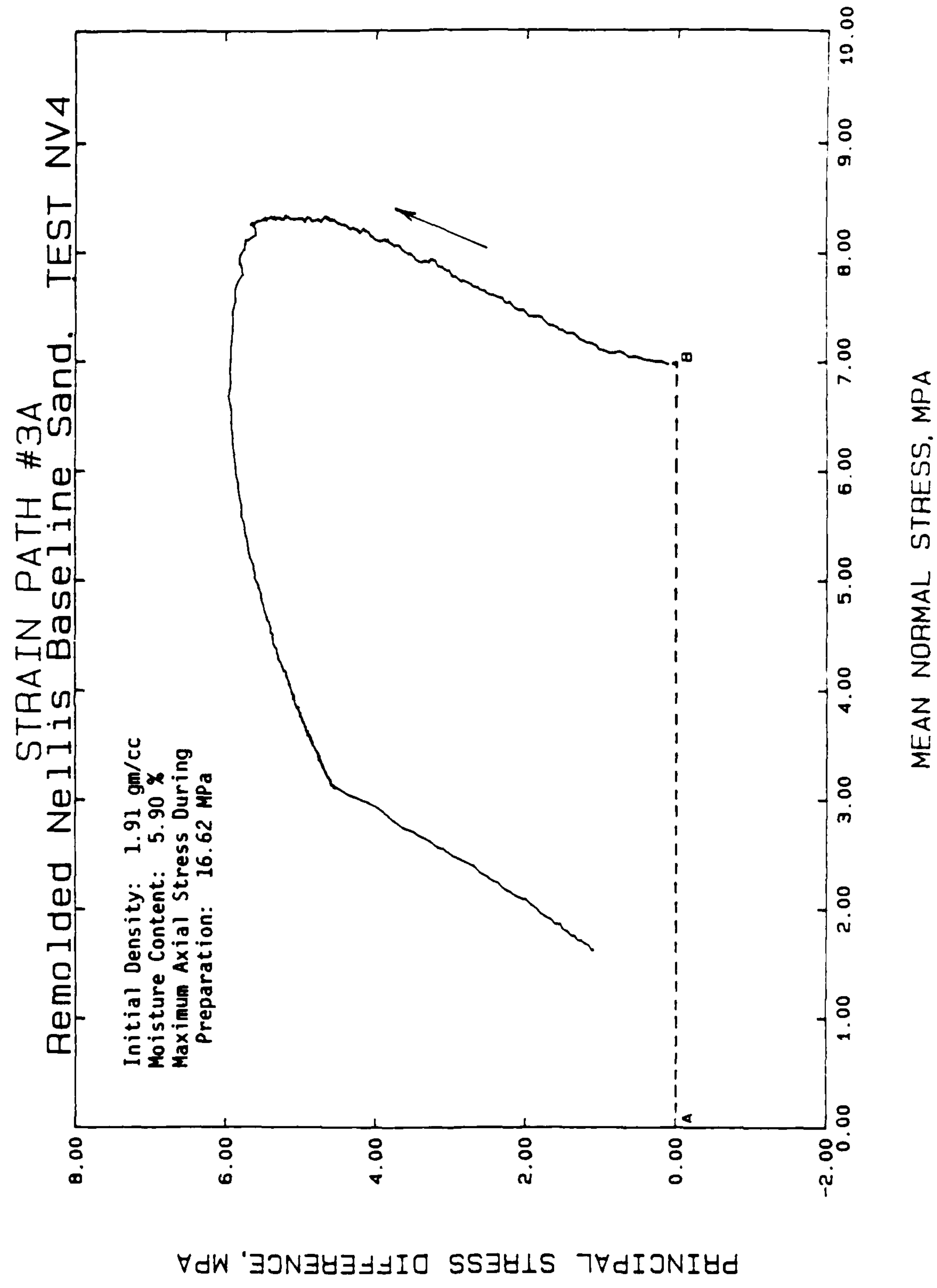
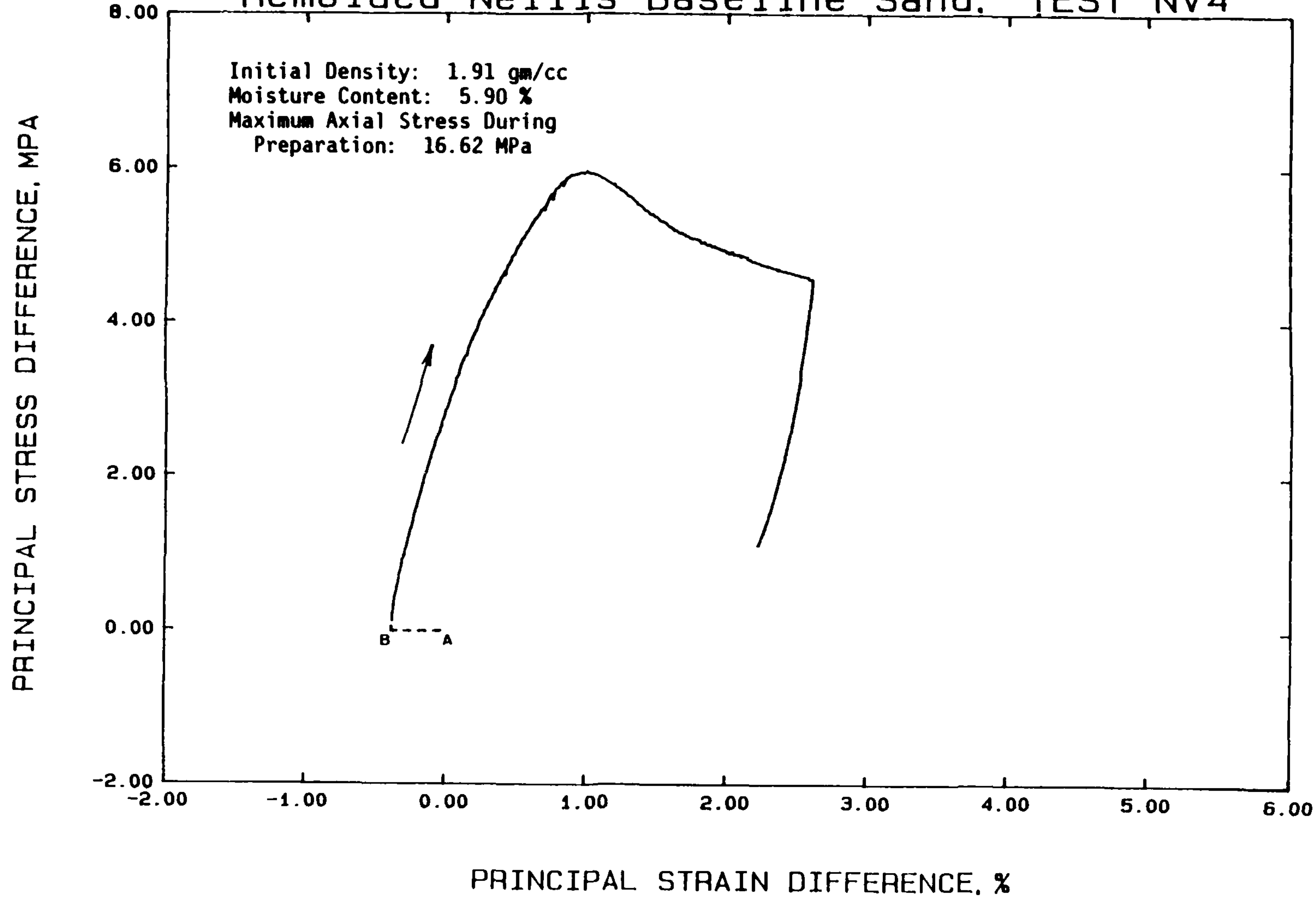

STRAIN PATH #3A
Remoulded Nellis Baseline Sand, TEST NV4
Initial Density: 1.91 gm/cc
Moisture Content: 5.90 %
Maximum Axial Stress During
Preparation: 16.62 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200

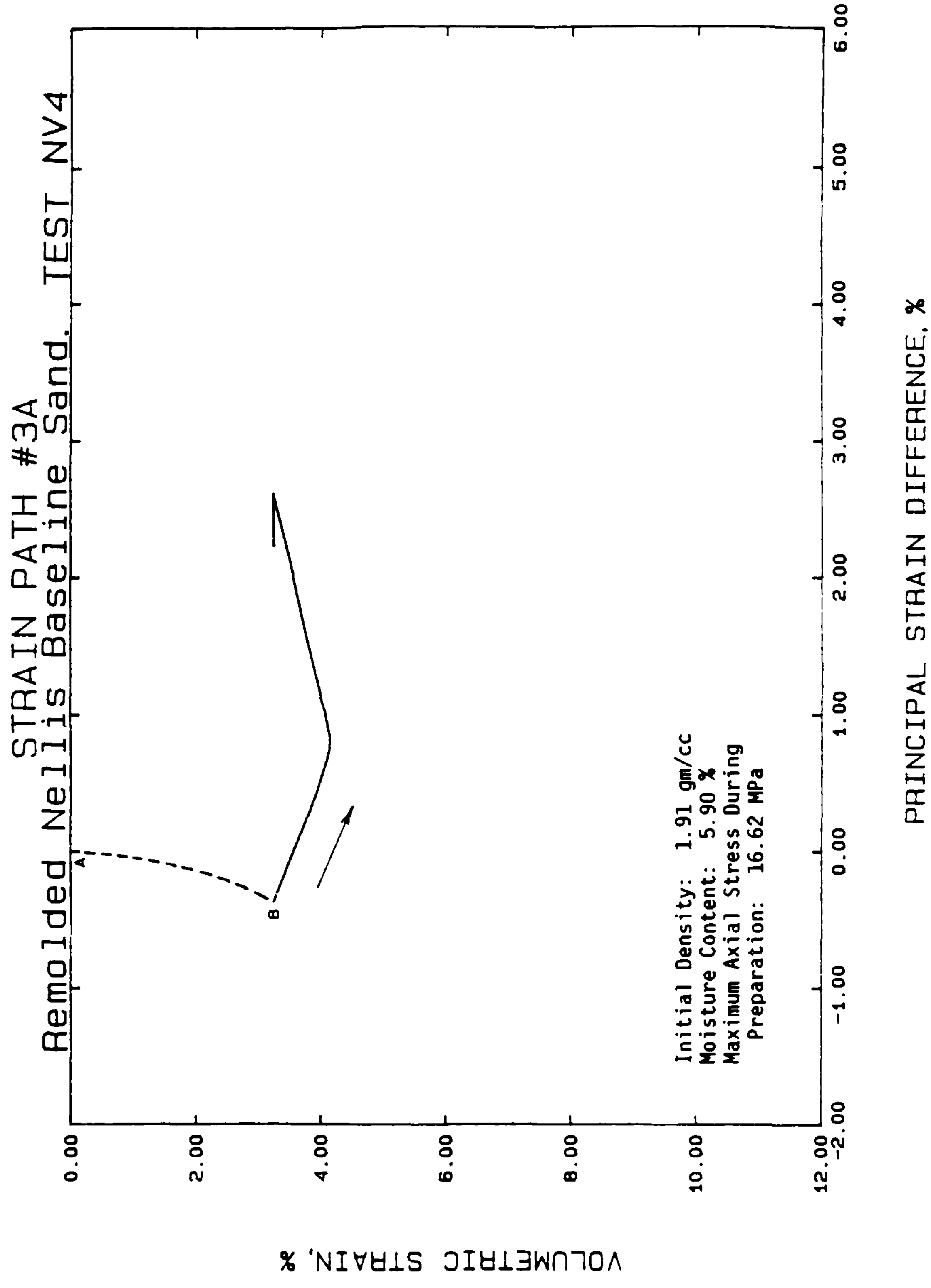
Plate 130



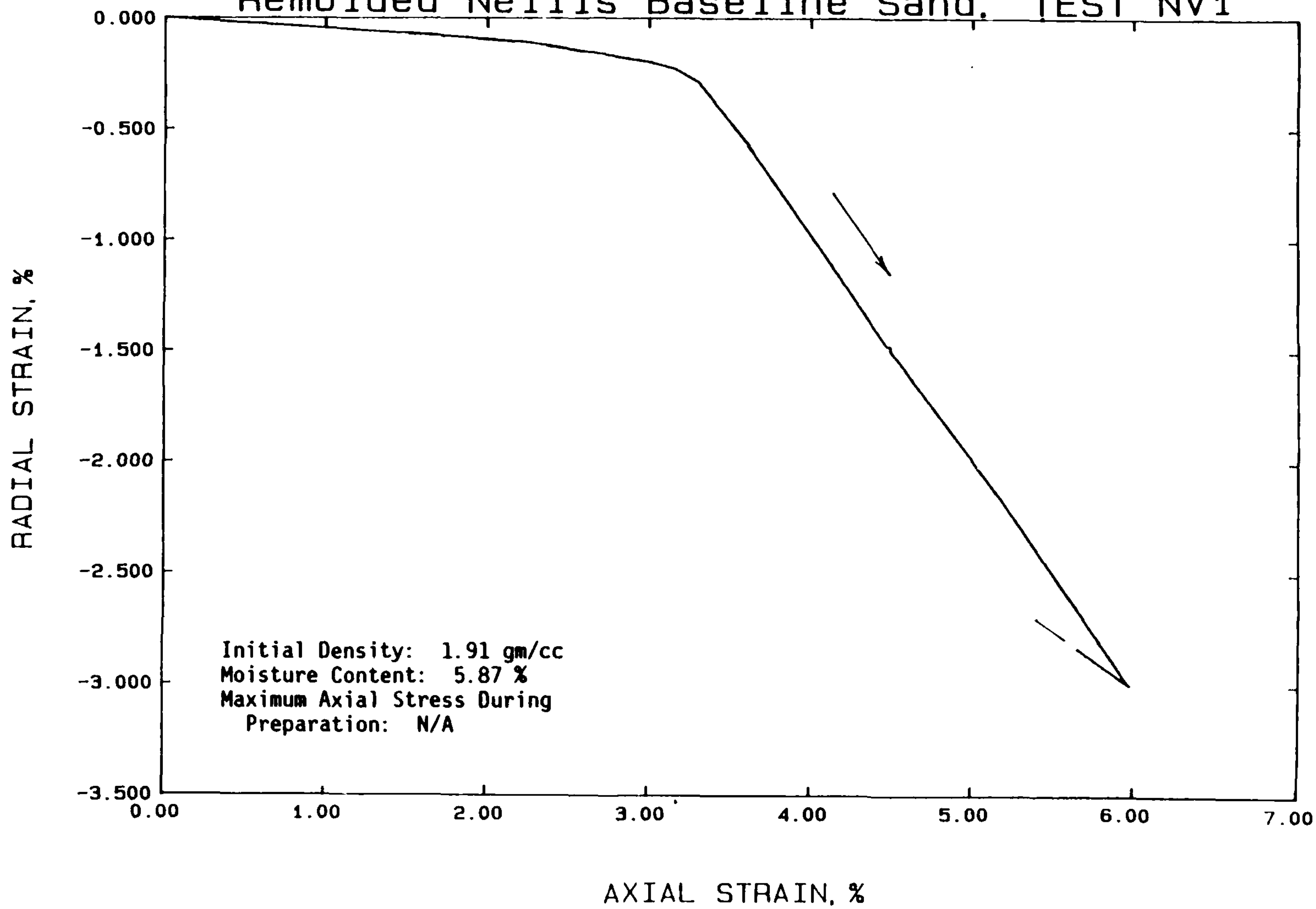
STRAIN PATH #3A
Remolded Nellis Baseline Sand. TEST NV4
Initial Density: 1.91 gm/cc
Moisture Content: 5.90 %
Maximum Axial Stress During
Preparation: 16.62 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00

STRAIN PATH #3A
Remolded Nellis Baseline Sand, TEST NV4




STRAIN PATH #3A
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.91 gm/cc
Moisture Content: 5.90 %
Maximum Axial Stress During
Preparation: 16.62 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00

STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV1



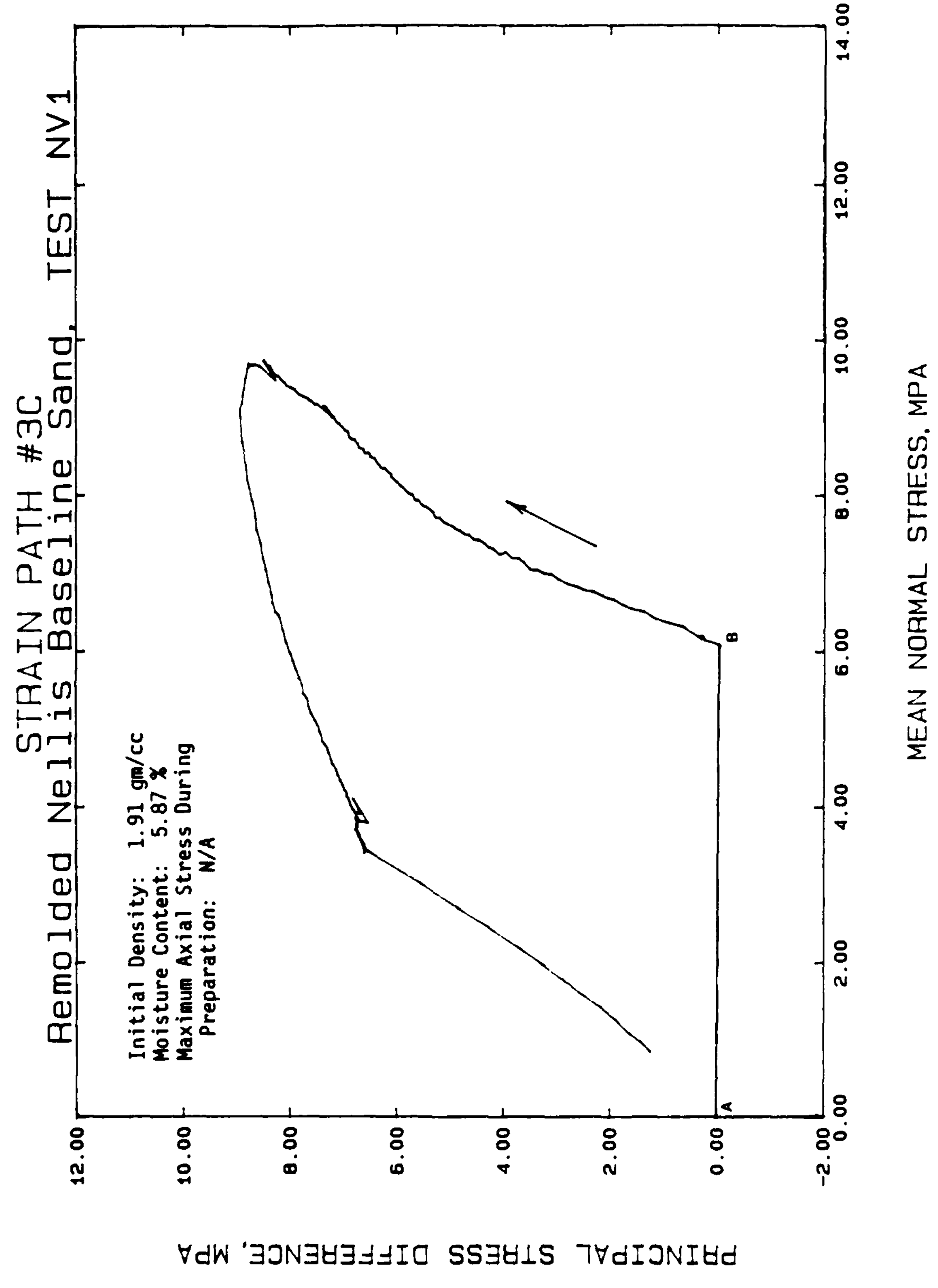

STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.91 gm/cc
Moisture Content: 5.87 %
Maximum Axial Stress During
Preparation: N/A
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
MEAN NORMAL STRESS, MPA
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 135

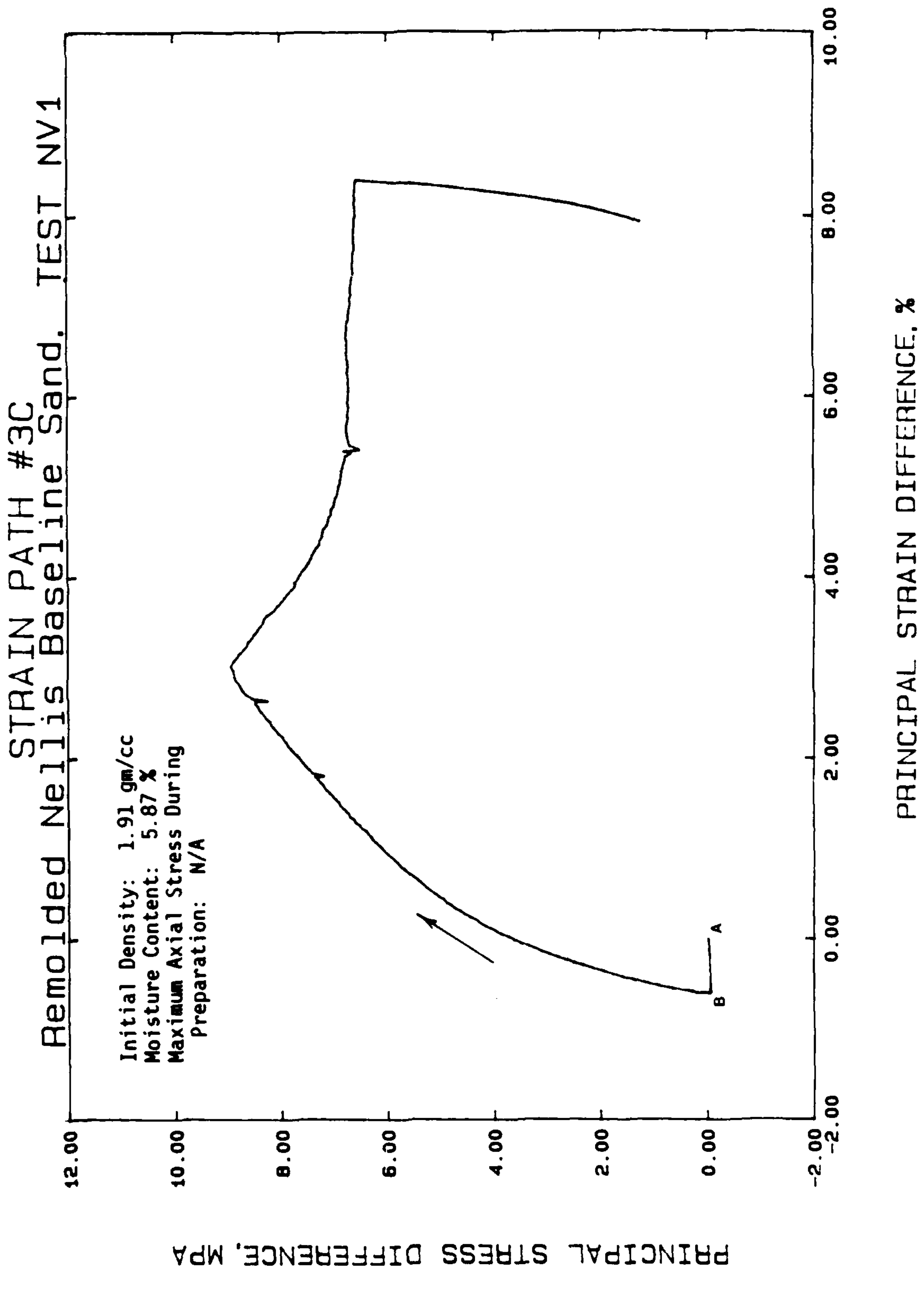
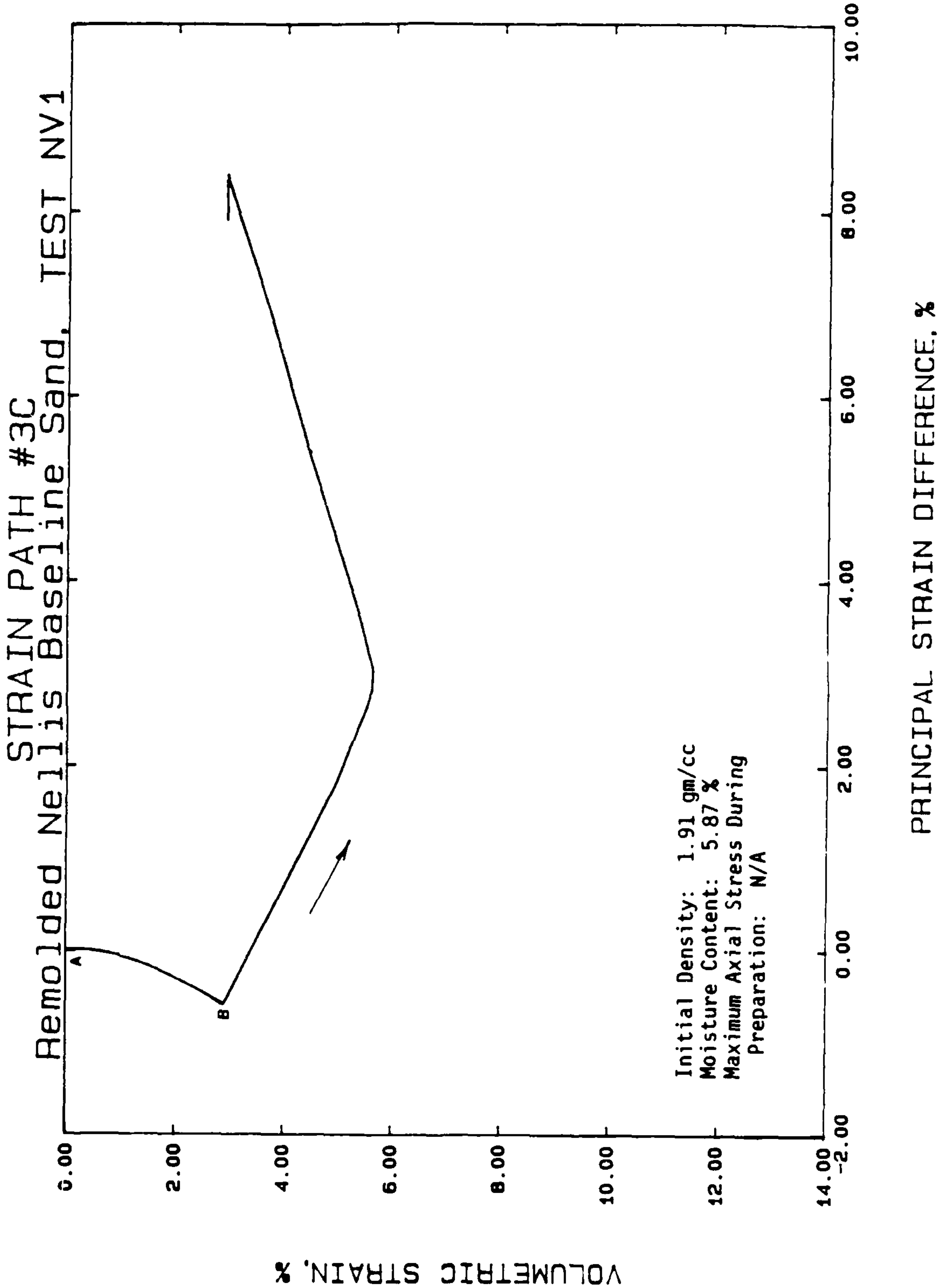
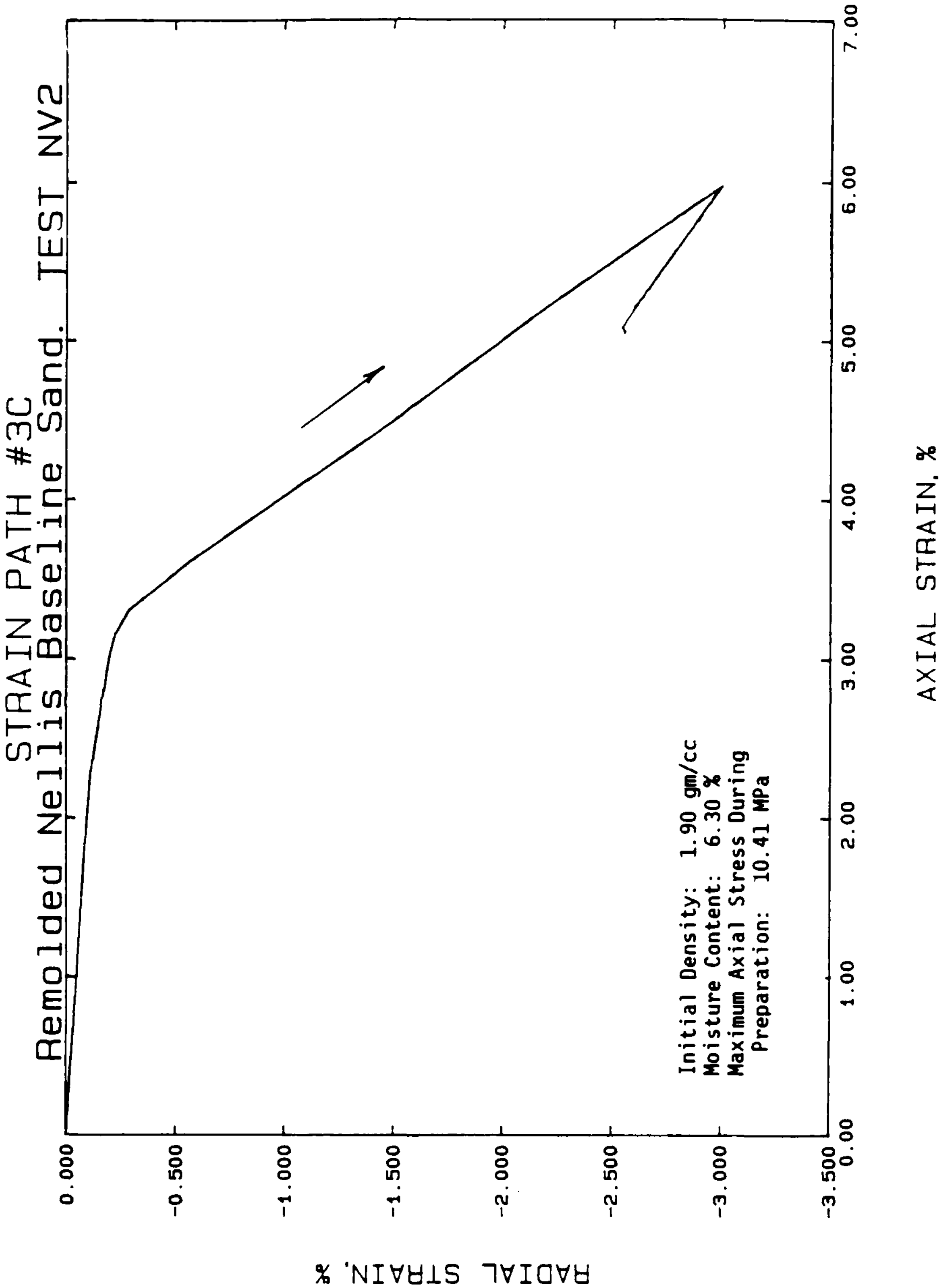

STRAIN PATH #3C
Remolded Nellis Baseline Sand. TEST NV1
Initial Density: 1.91 gm/cc
Moisture Content: 5.87 %
Maximum Axial Stress During
Preparation: N/A
A
B
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %

Plate 136



STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV1
Initial Density: 1.91 gm/cc
Moisture Content: 5.87 %
Maximum Axial Stress During
Preparation: N/A
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 137



STRAIN PATH #3C
Remolded Nellis Baseline Sand. TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 6.30 %
Maximum Axial Stress During
Preparation: 10.41 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
-3.500

Plate 138

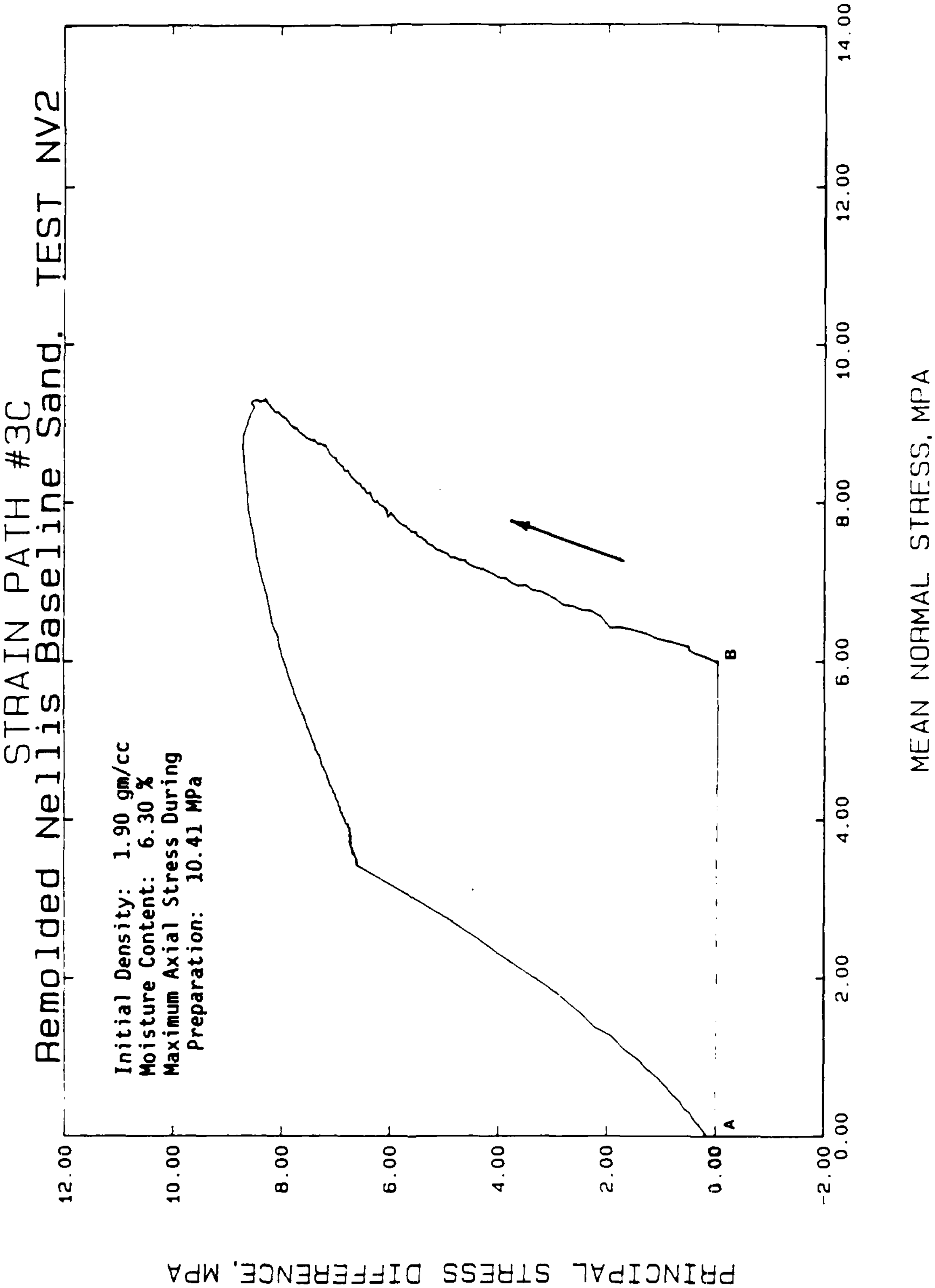

STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 6.30 %
Maximum Axial Stress During
Preparation: 10.41 MPa
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
MEAN NORMAL STRESS, MPA
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 139

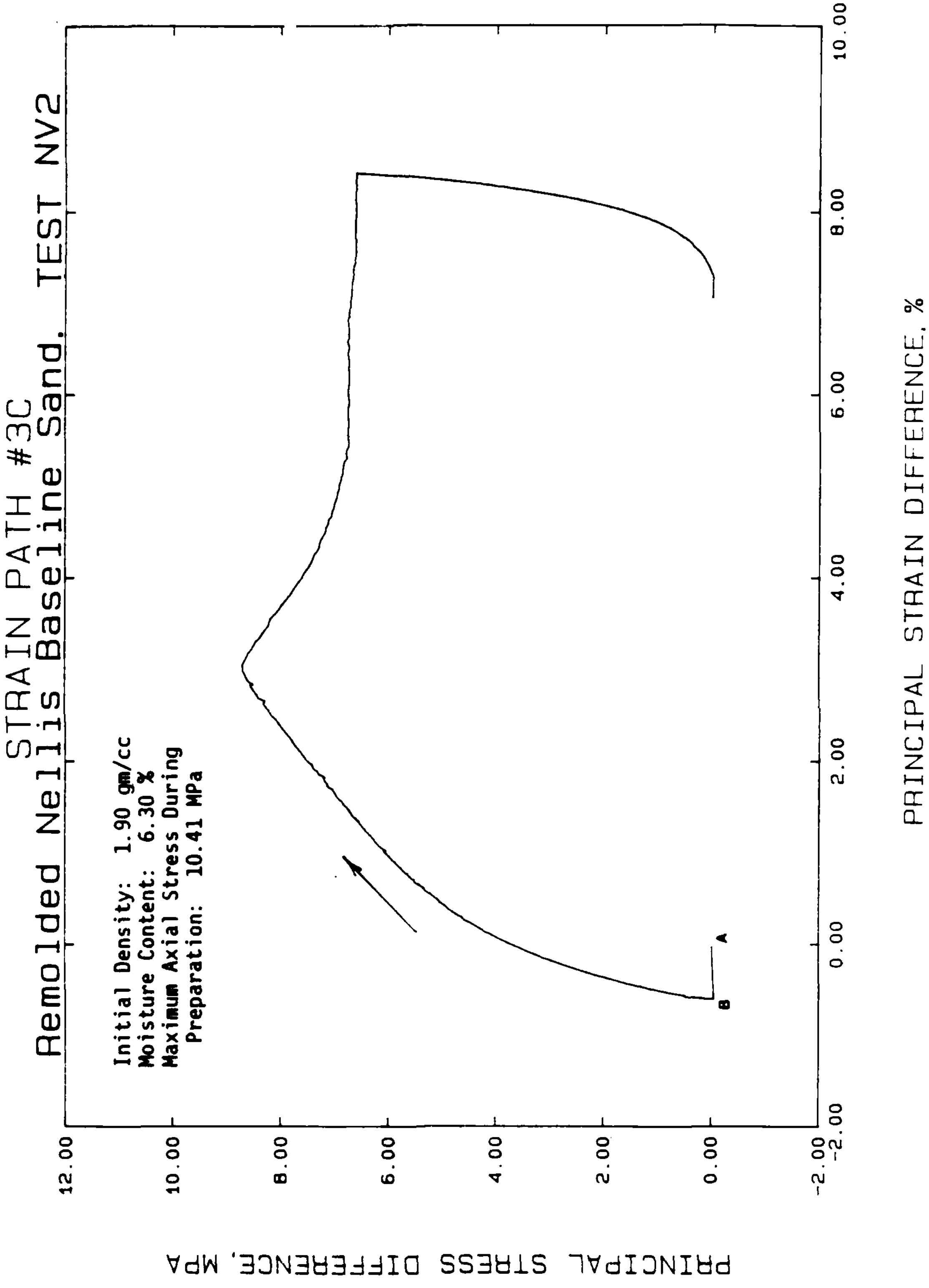

STRAIN PATH #3C
Remolded Nellis Baseline Sand. TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 6.30 %
Maximum Axial Stress During
Preparation: 10.41 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00

Plate 140

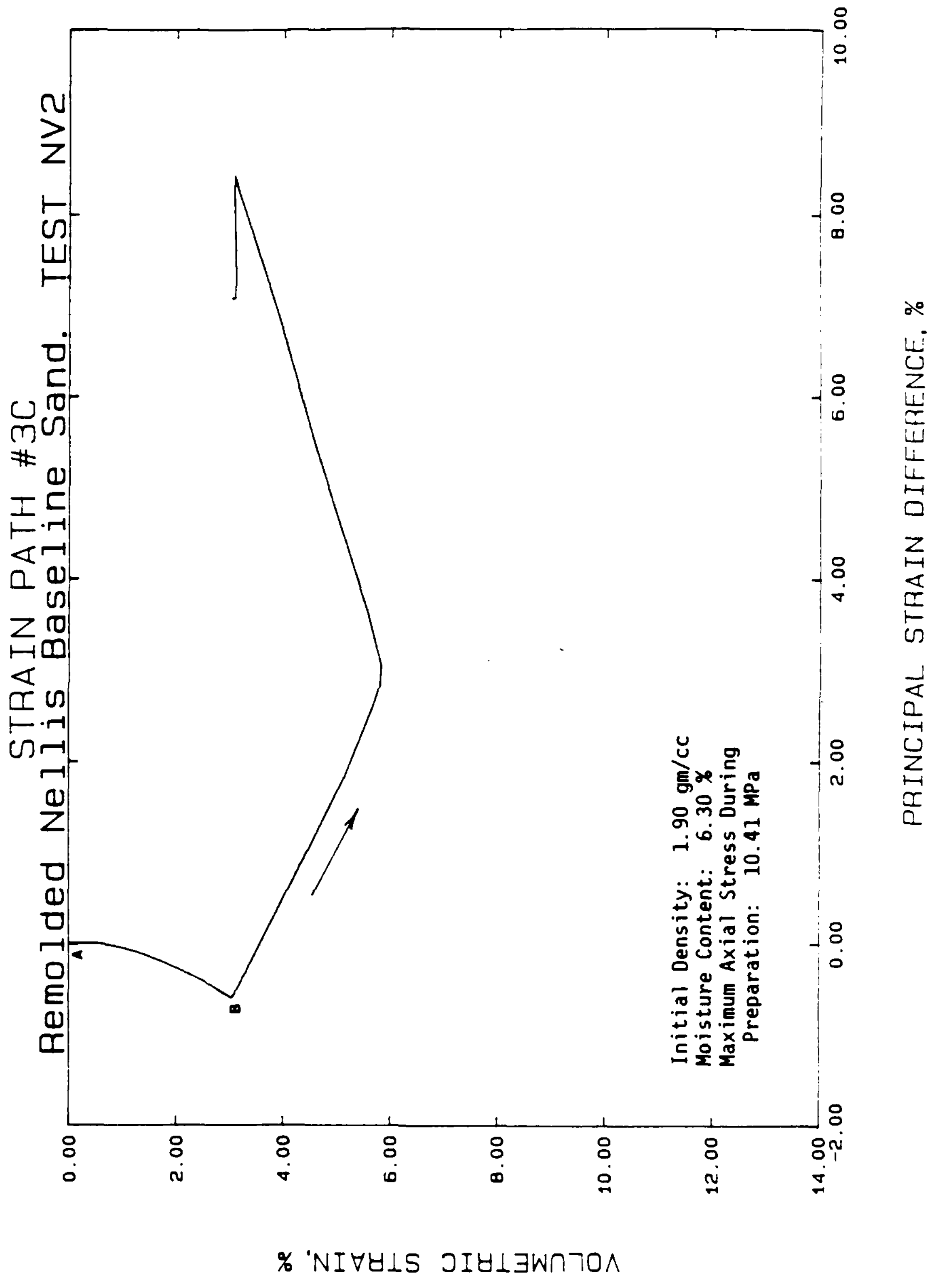
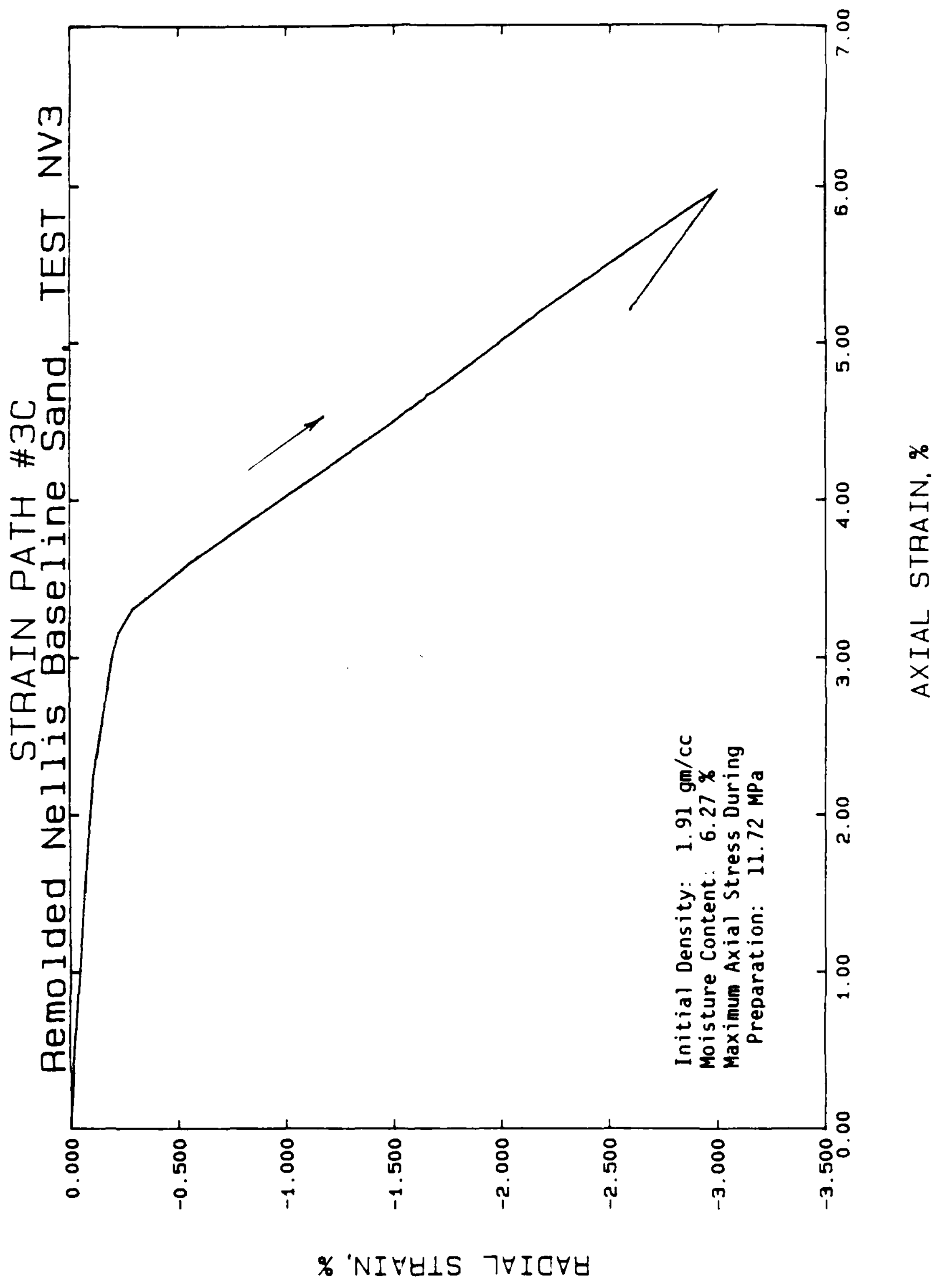
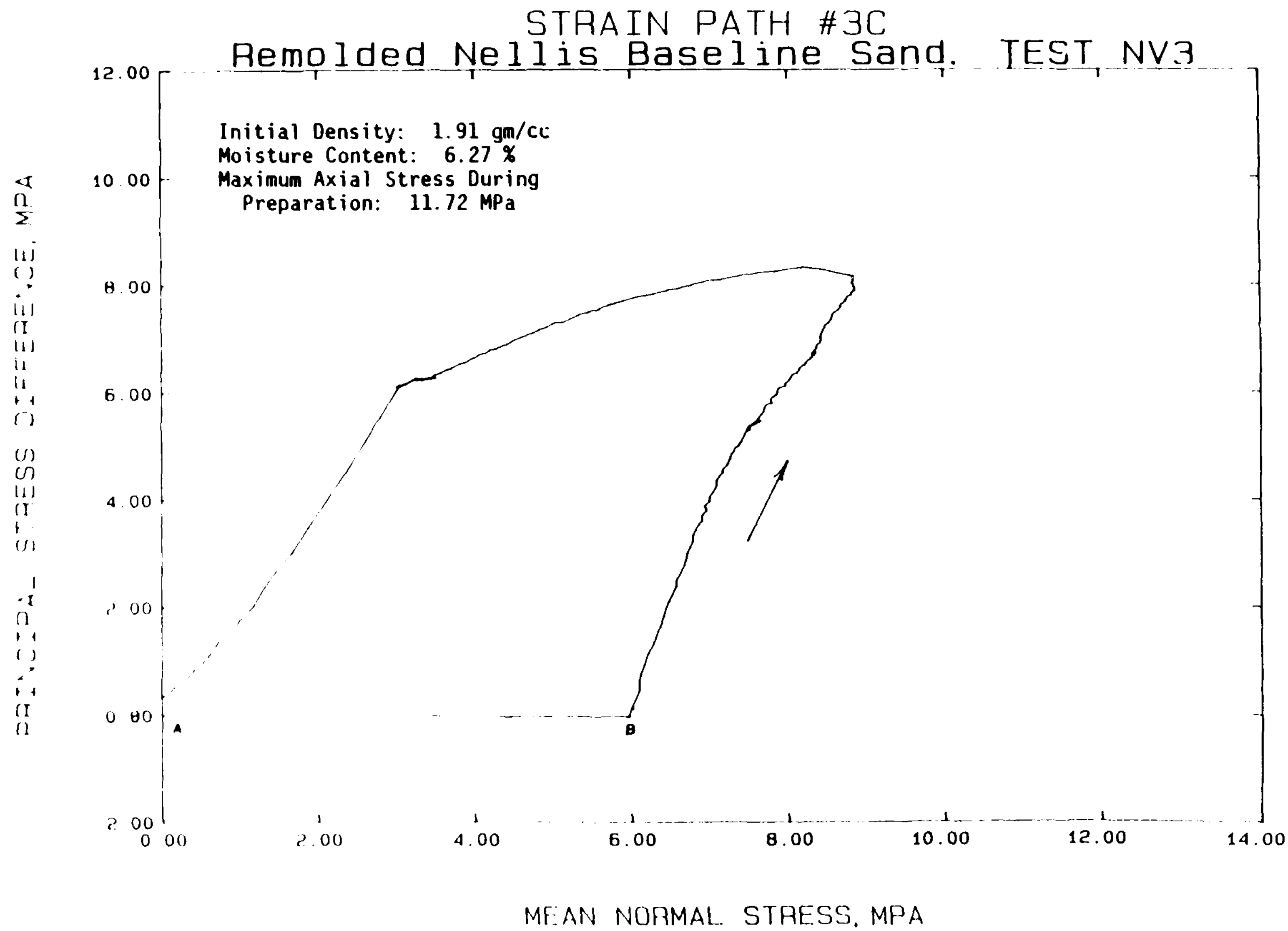

STRAIN PATH #3C
Remolded Nellis Baseline Sand. TEST NV2
Initial Density: 1.90 gm/cc
Moisture Content: 6.30 %
Maximum Axial Stress During
Preparation: 10.41 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00

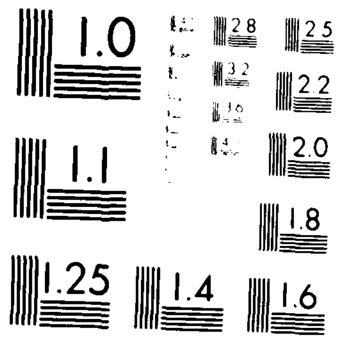
Plate 141



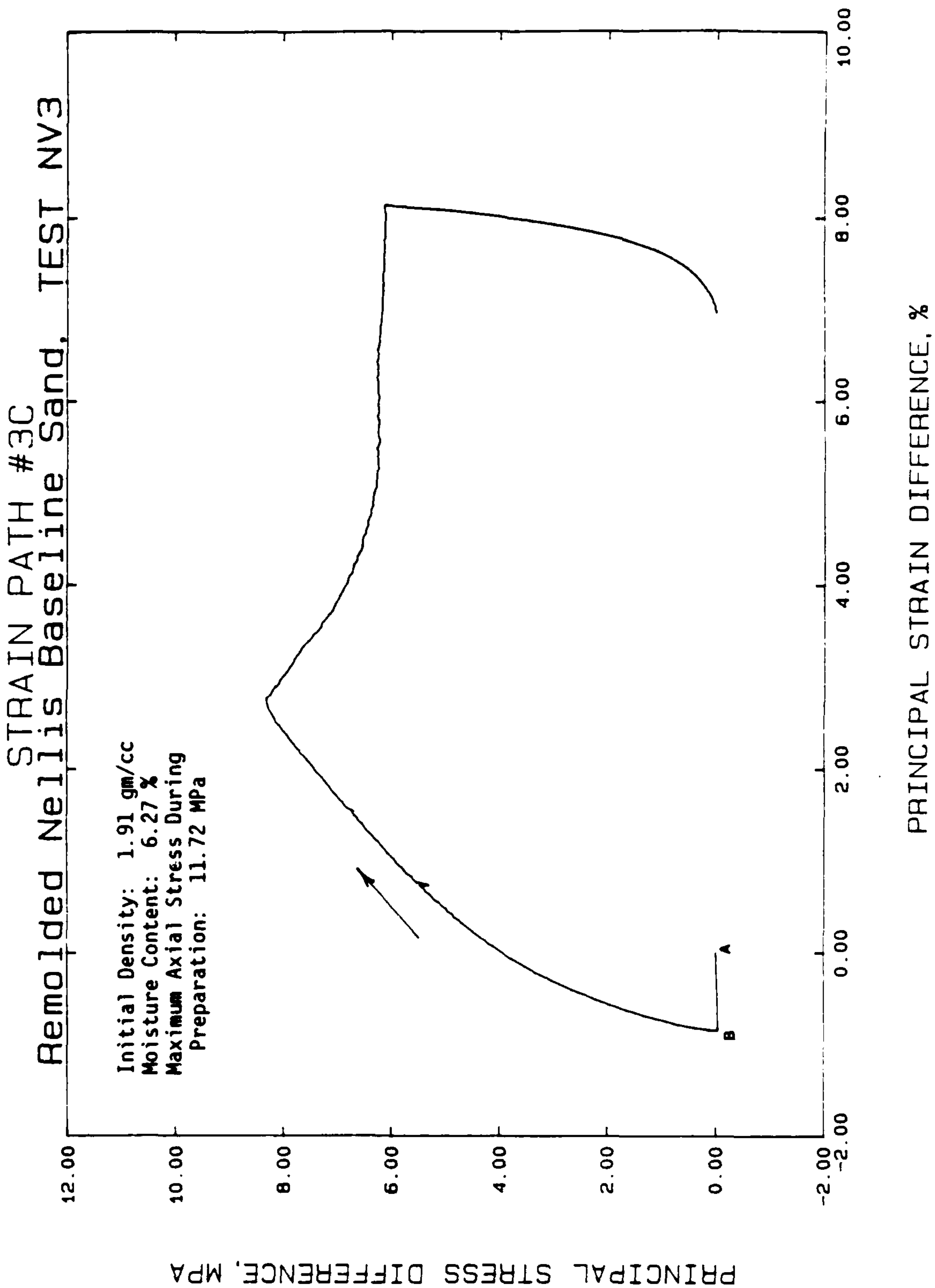
STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV3
Initial Density: 1.91 gm/cc
Moisture Content: 6.27 %
Maximum Axial Stress During
Preparation: 11.72 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
-3.500


STRAIN PATH #3C
Remolded Nellis Baseline Sand. TEST NV3
Initial Density: 1.91 gm/cc
Moisture Content: 6.27 %
Maximum Axial Stress During
Preparation: 11.72 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
A
B

AD-A180 755 MECHANICAL PROPERTIES OF ALLUVIUM FROM NELLIS AIR FORCE 3/4
RANGE NEVADA; LUK..(U) TERRA TEK INC SALT LAKE CITY UT
J B WANGSGARD ET AL. 14 OCT 86 TR-86-76 DNA-TR-87-68
UNCLASSIFIED DNA001-83-C-0193 F/G 8/10 NL



MICROCOPY RESOLUTION TEST CHART


STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV3
Initial Density: 1.91 gm/cc
Moisture Content: 6.27 %
Maximum Axial Stress During
Preparation: 11.72 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA

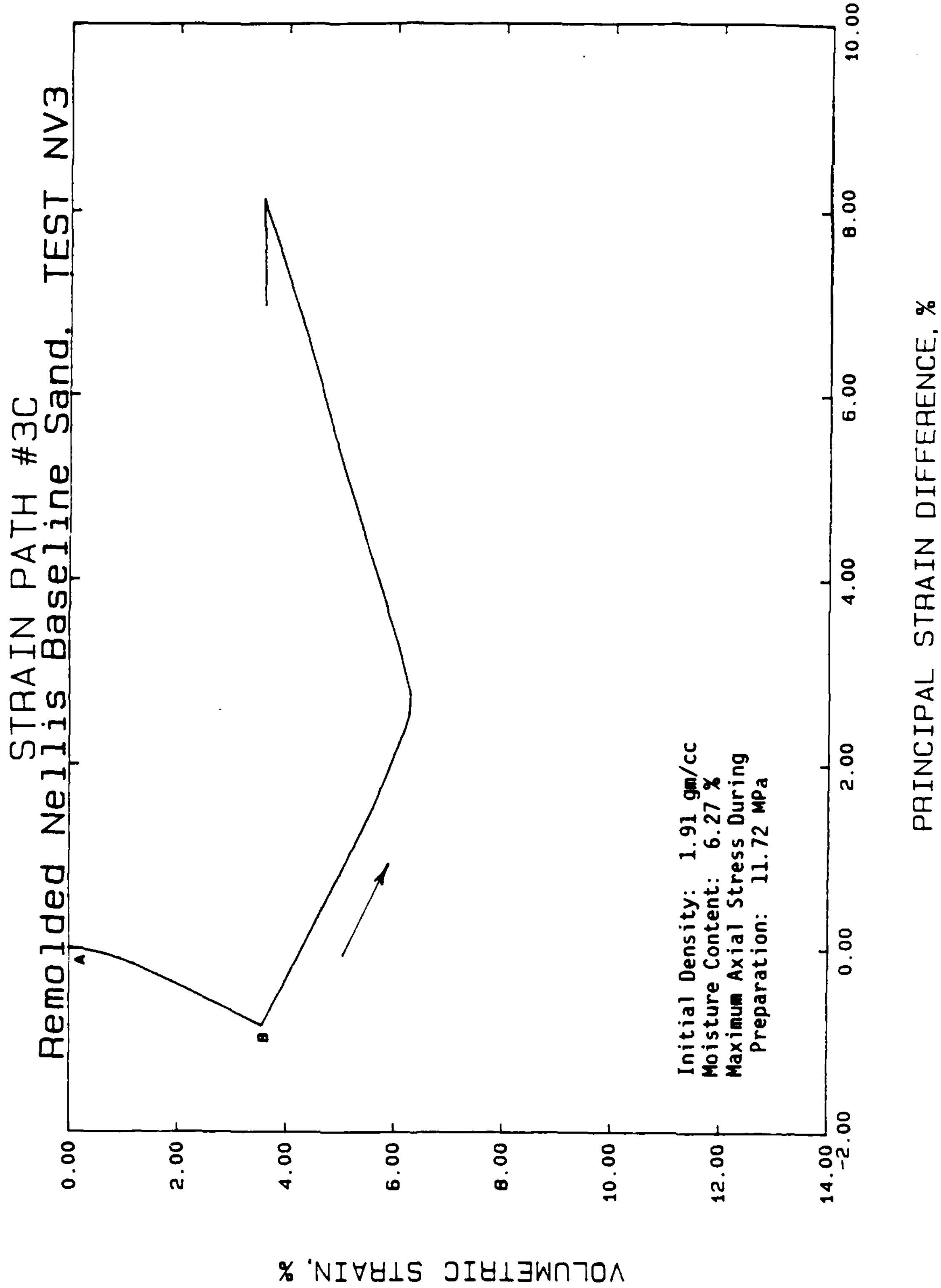

STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV3
A
B
Initial Density: 1.91 gm/cc
Moisture Content: 6.27 %
Maximum Axial Stress During
Preparation: 11.72 MPa
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %

Plate 145

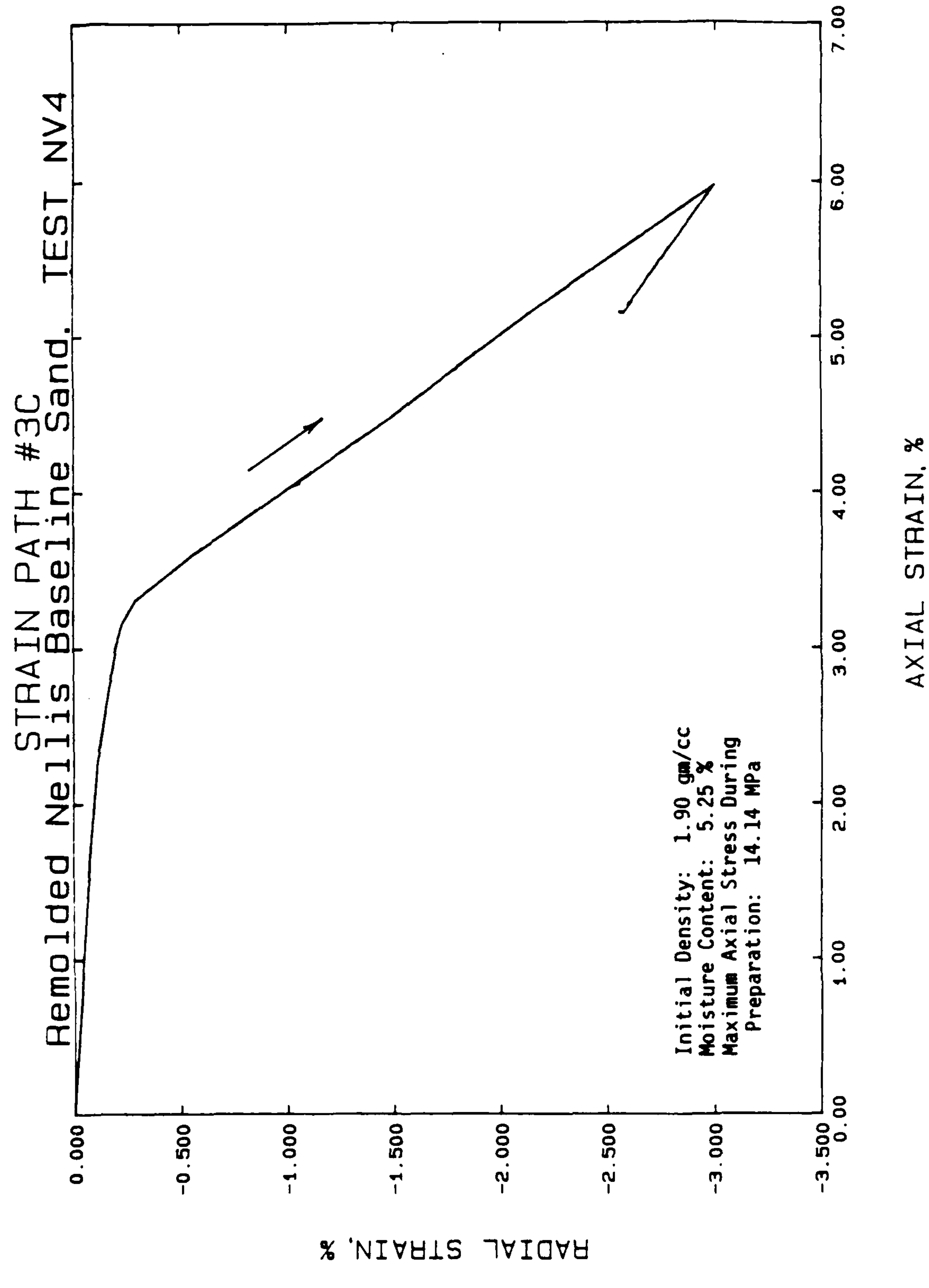
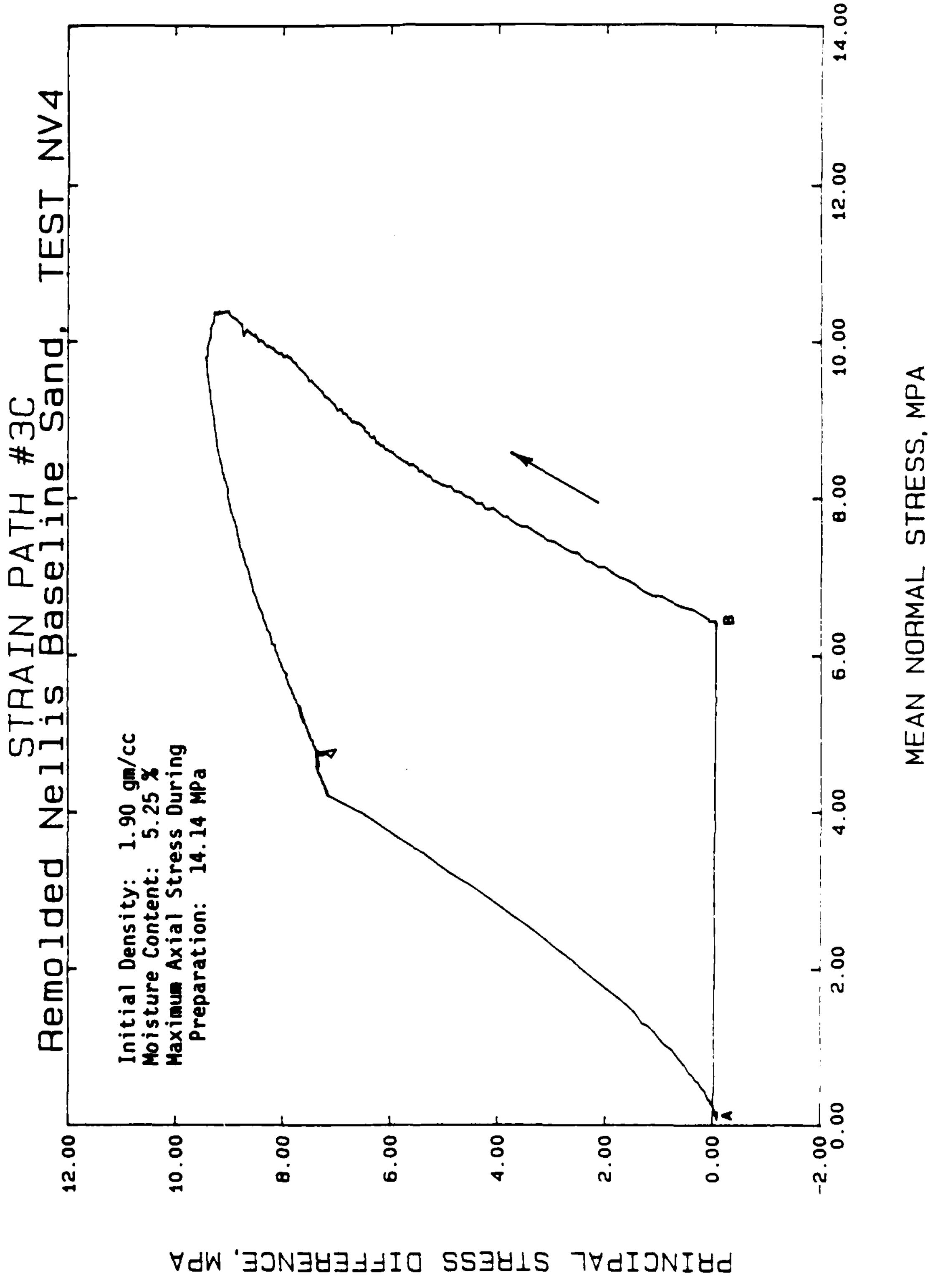
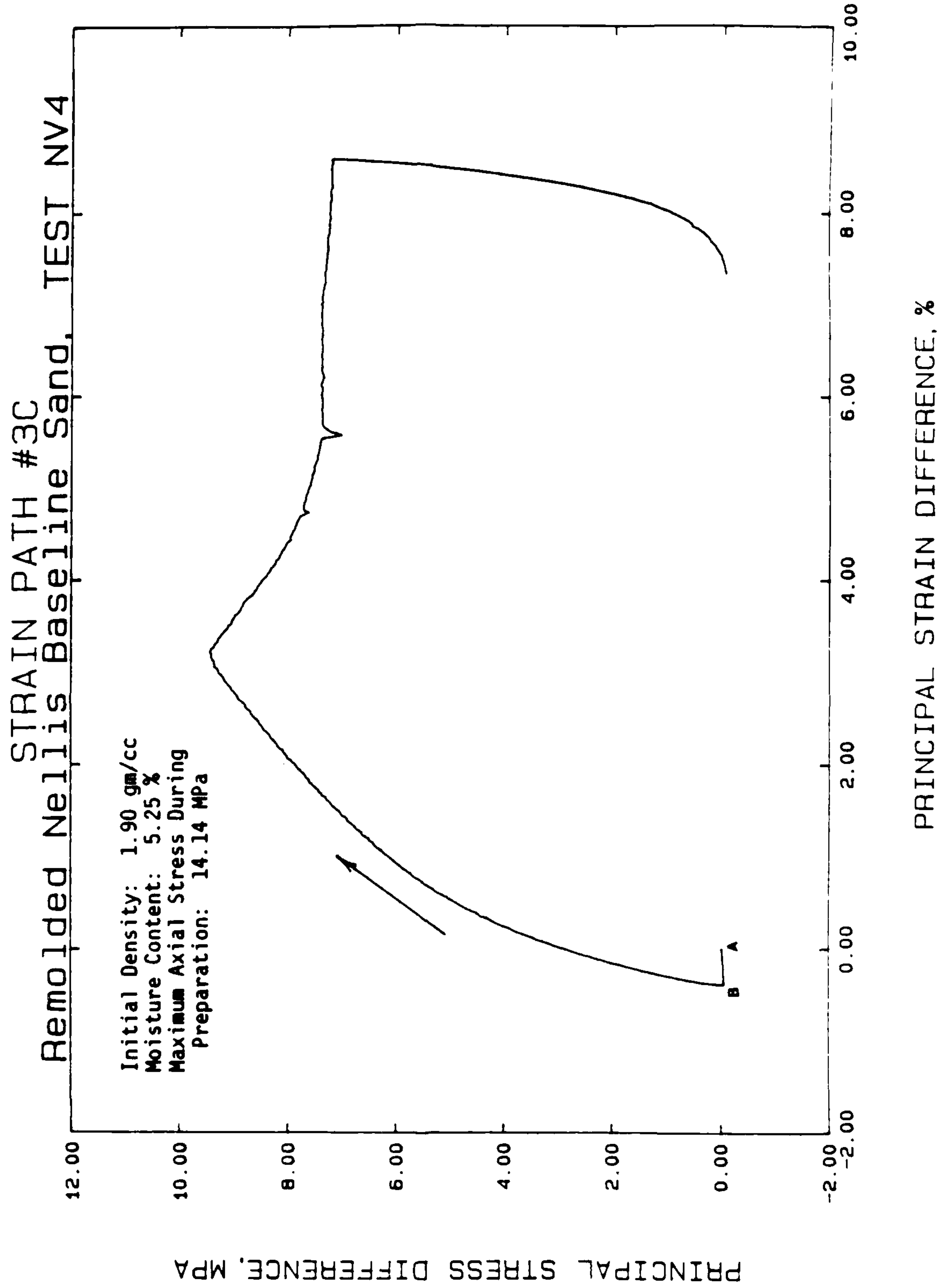

STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 5.25 %
Maximum Axial Stress During
Preparation: 14.14 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
-3.500

Plate 146



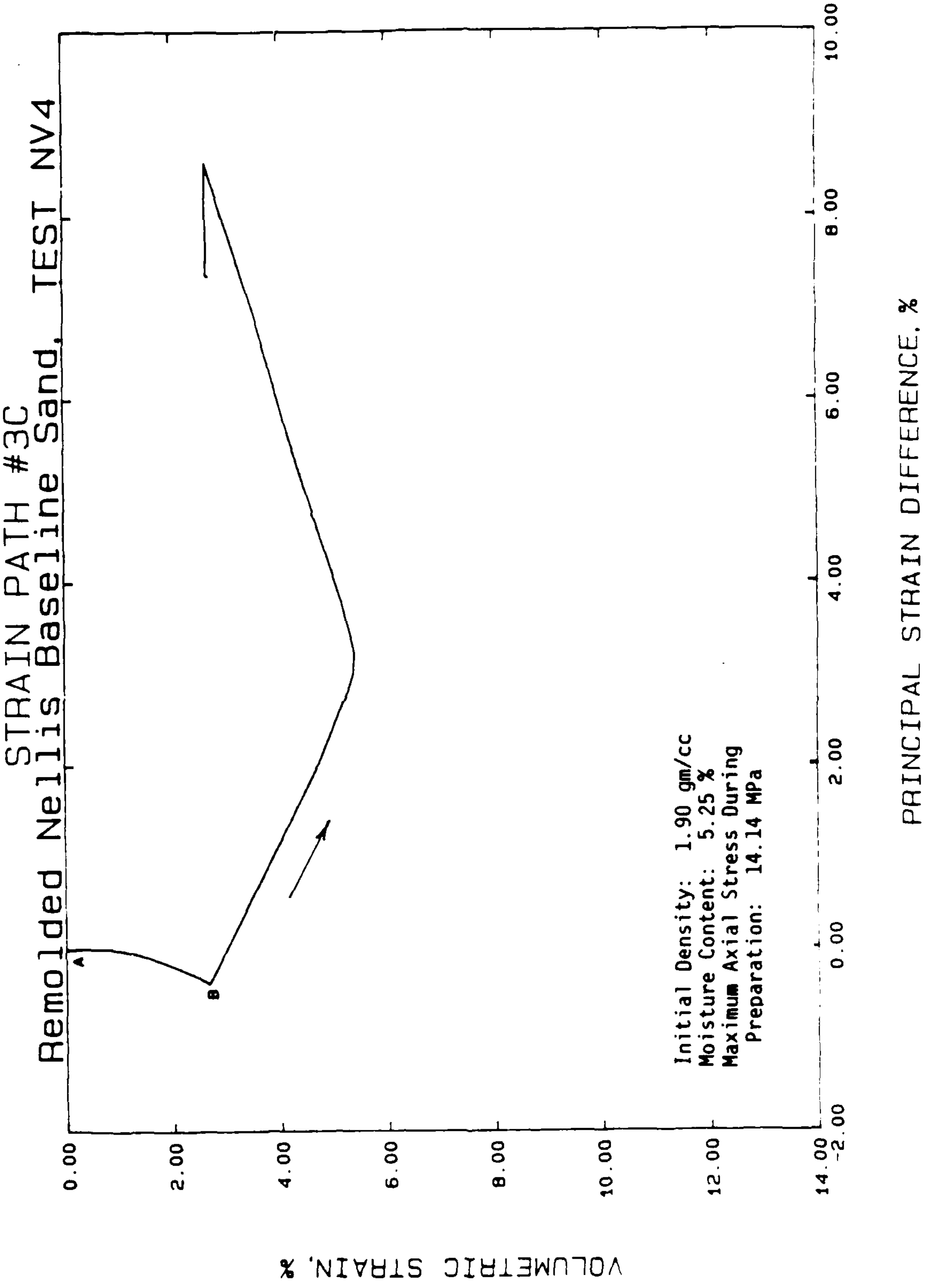
STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 5.25 %
Maximum Axial Stress During
Preparation: 14.14 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
MEAN NORMAL STRESS, MPA
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 147



STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 5.25 %
Maximum Axial Stress During
Preparation: 14.14 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00

Plate 148


STRAIN PATH #3C
Remolded Nellis Baseline Sand, TEST NV4
Initial Density: 1.90 gm/cc
Moisture Content: 5.25 %
Maximum Axial Stress During
Preparation: 14.14 MPa
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %

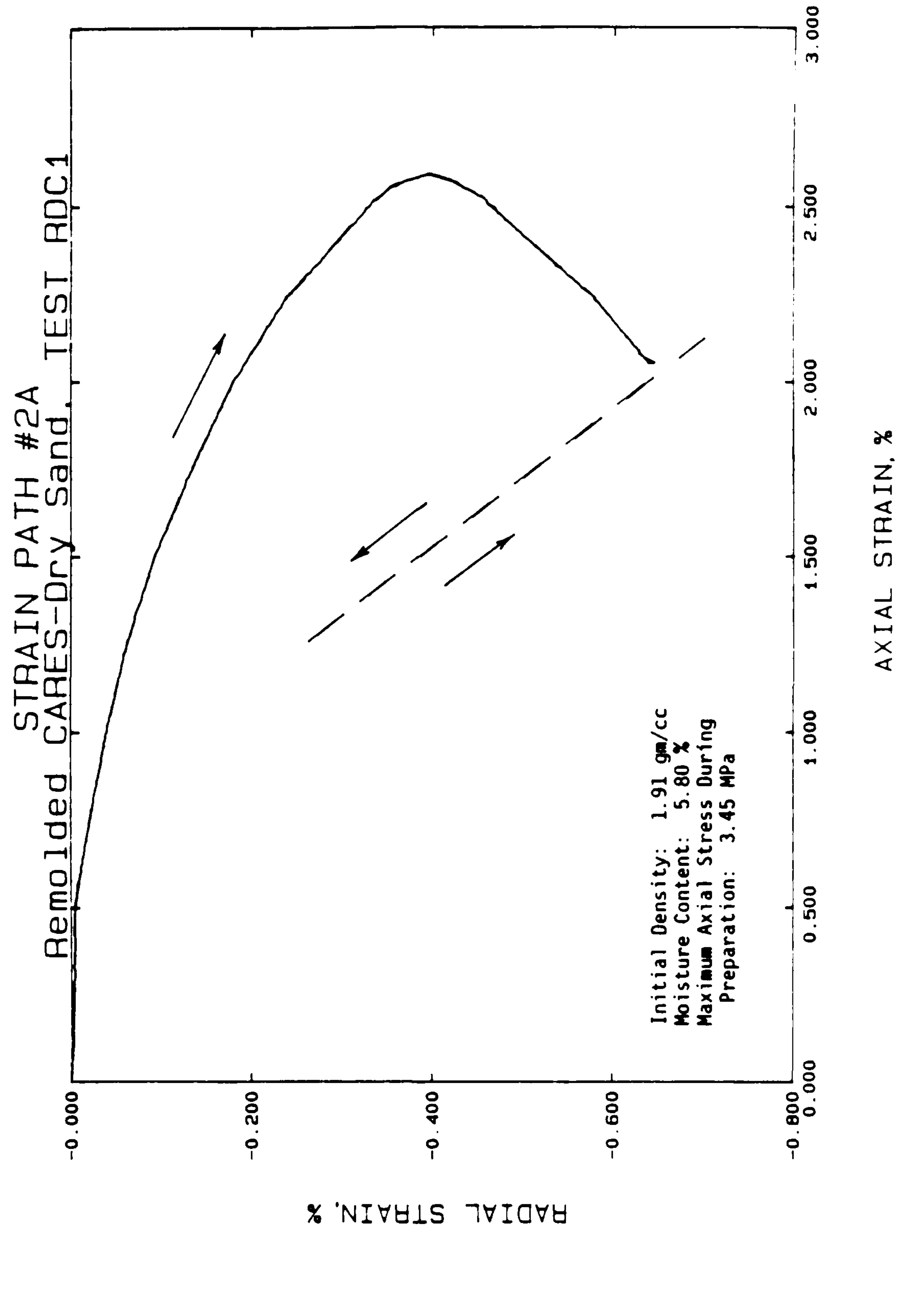
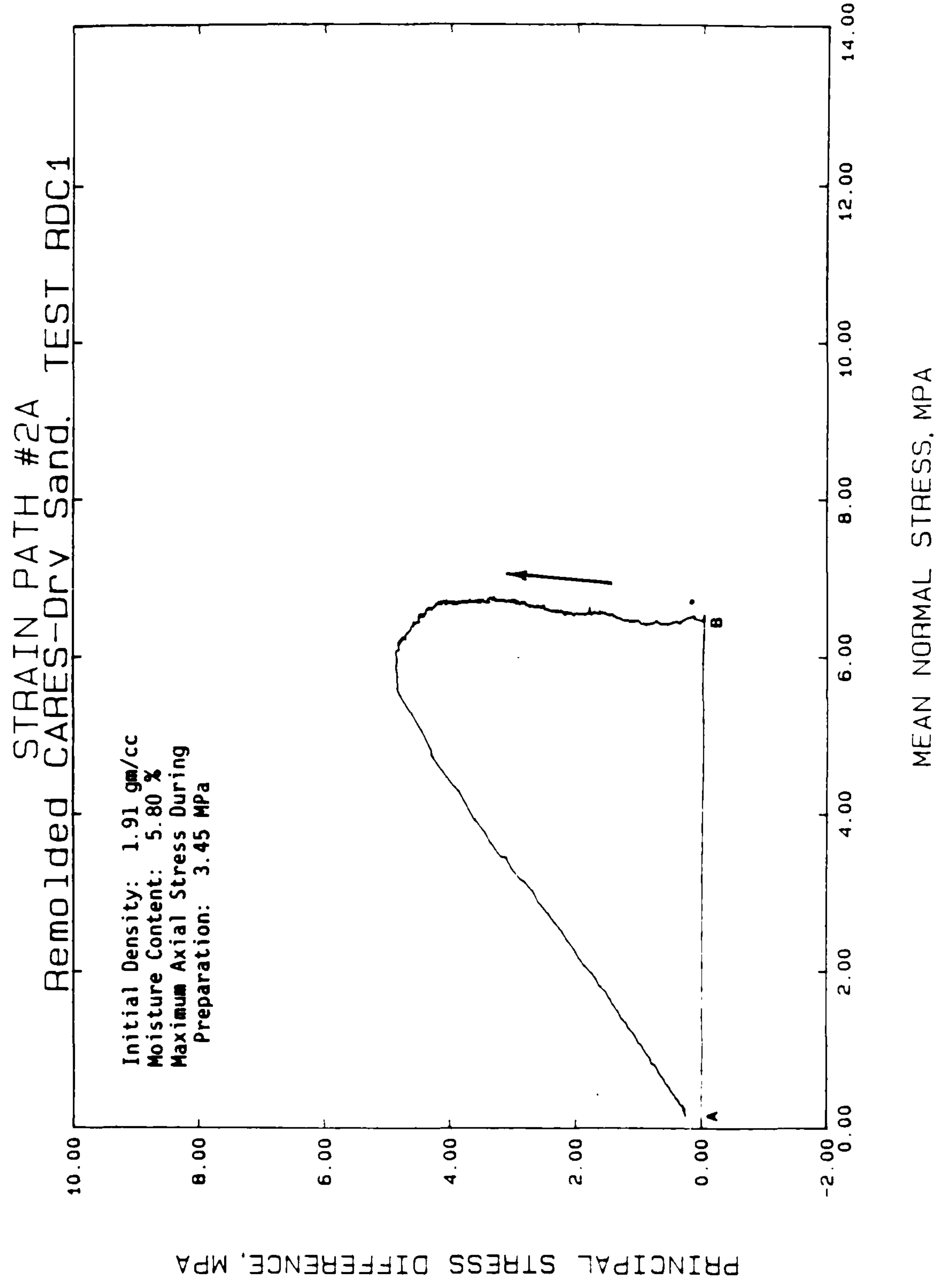

STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.91 gm/cc
Moisture Content: 5.80 %
Maximum Axial Stress During
Preparation: 3.45 MPa
0.000
0.500
1.000
1.500
2.000
2.500
3.000
AXIAL STRAIN, %
-0.000
-0.200
-0.400
-0.600
-0.800
RADIAL STRAIN, %

Plate 150



STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.91 gm/cc
Moisture Content: 5.80 %
Maximum Axial Stress During
Preparation: 3.45 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
MEAN NORMAL STRESS, MPA
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 151

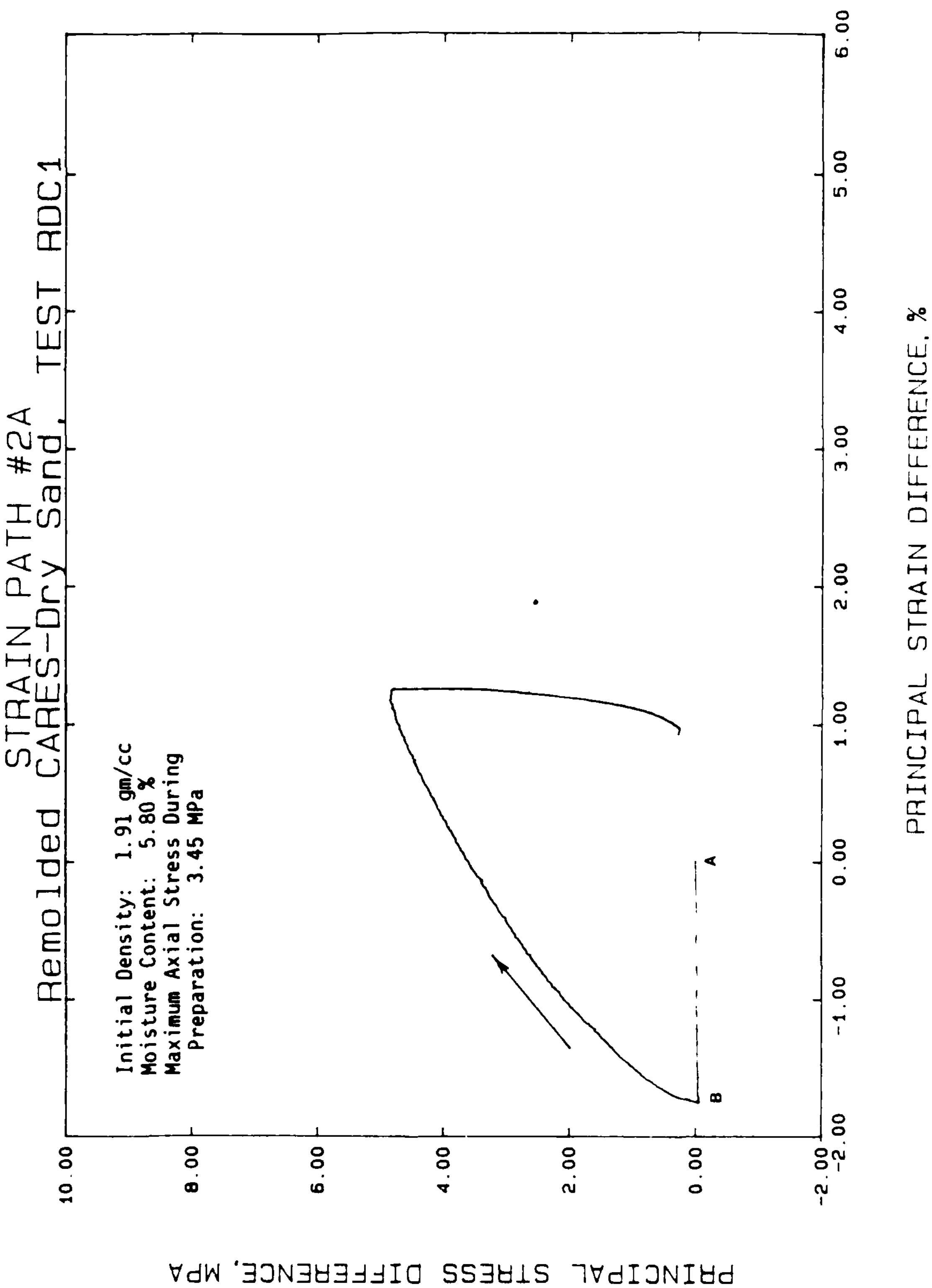

STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.91 gm/cc
Moisture Content: 5.80 %
Maximum Axial Stress During
Preparation: 3.45 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %

Plate 152

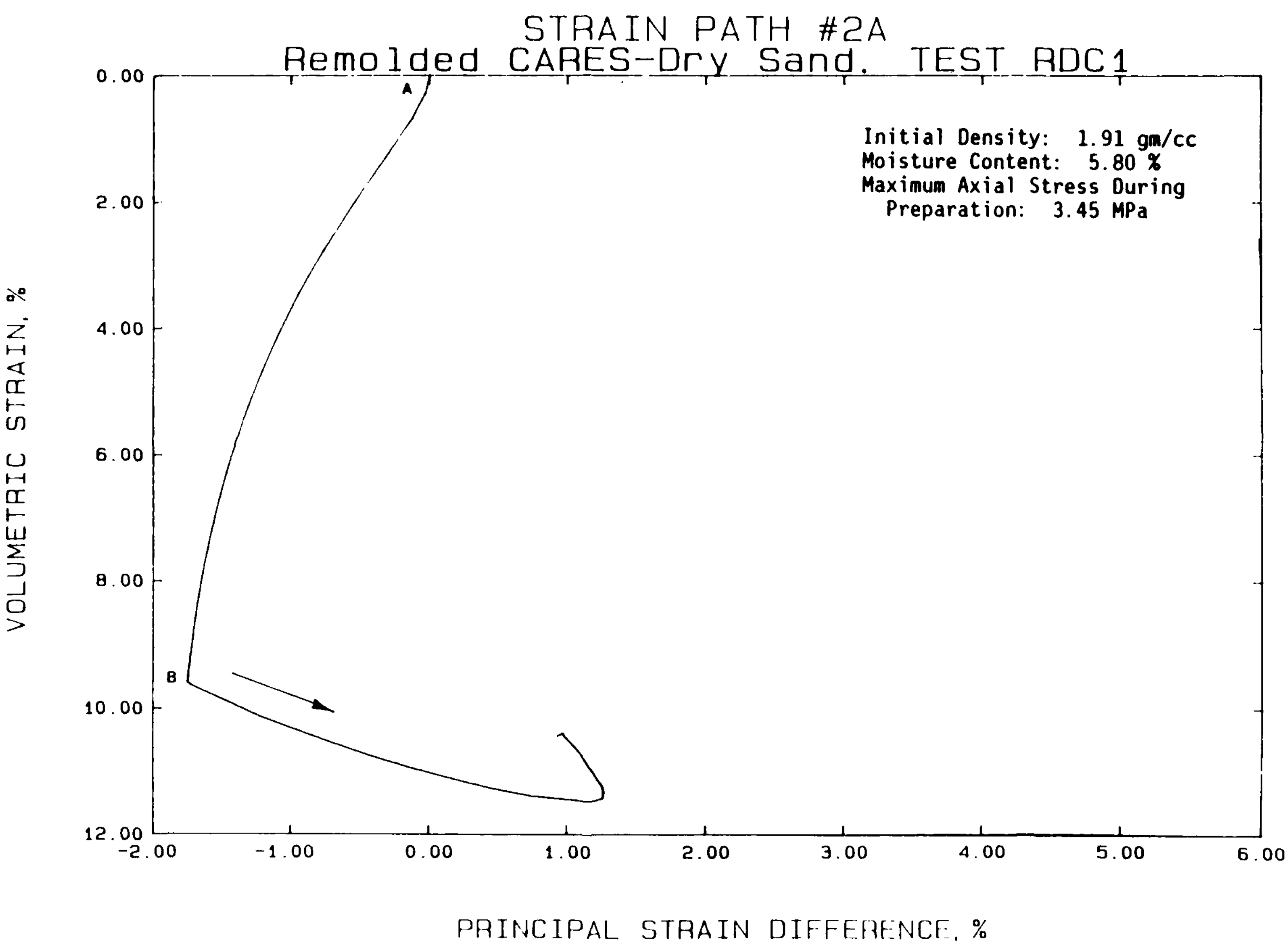
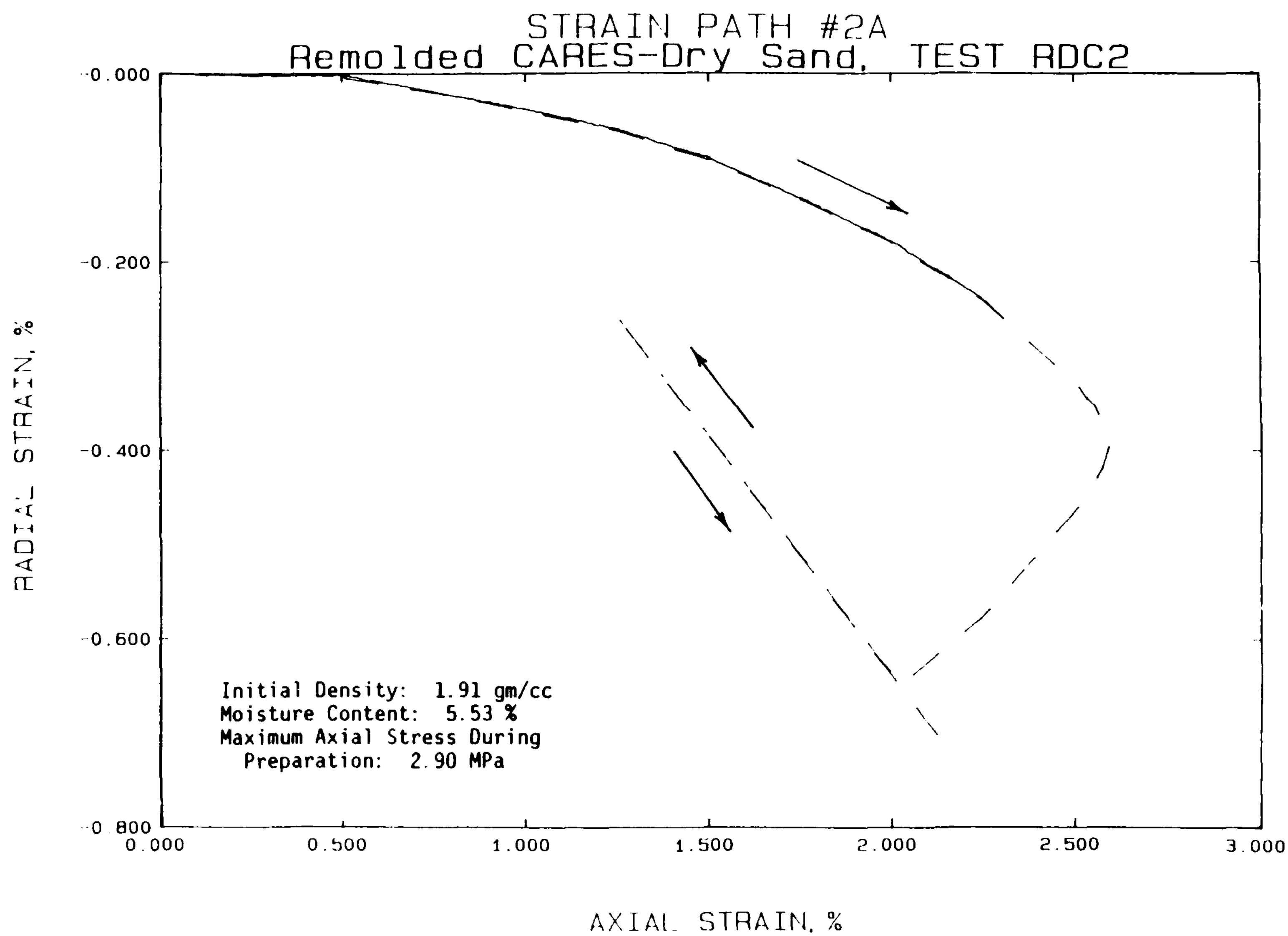
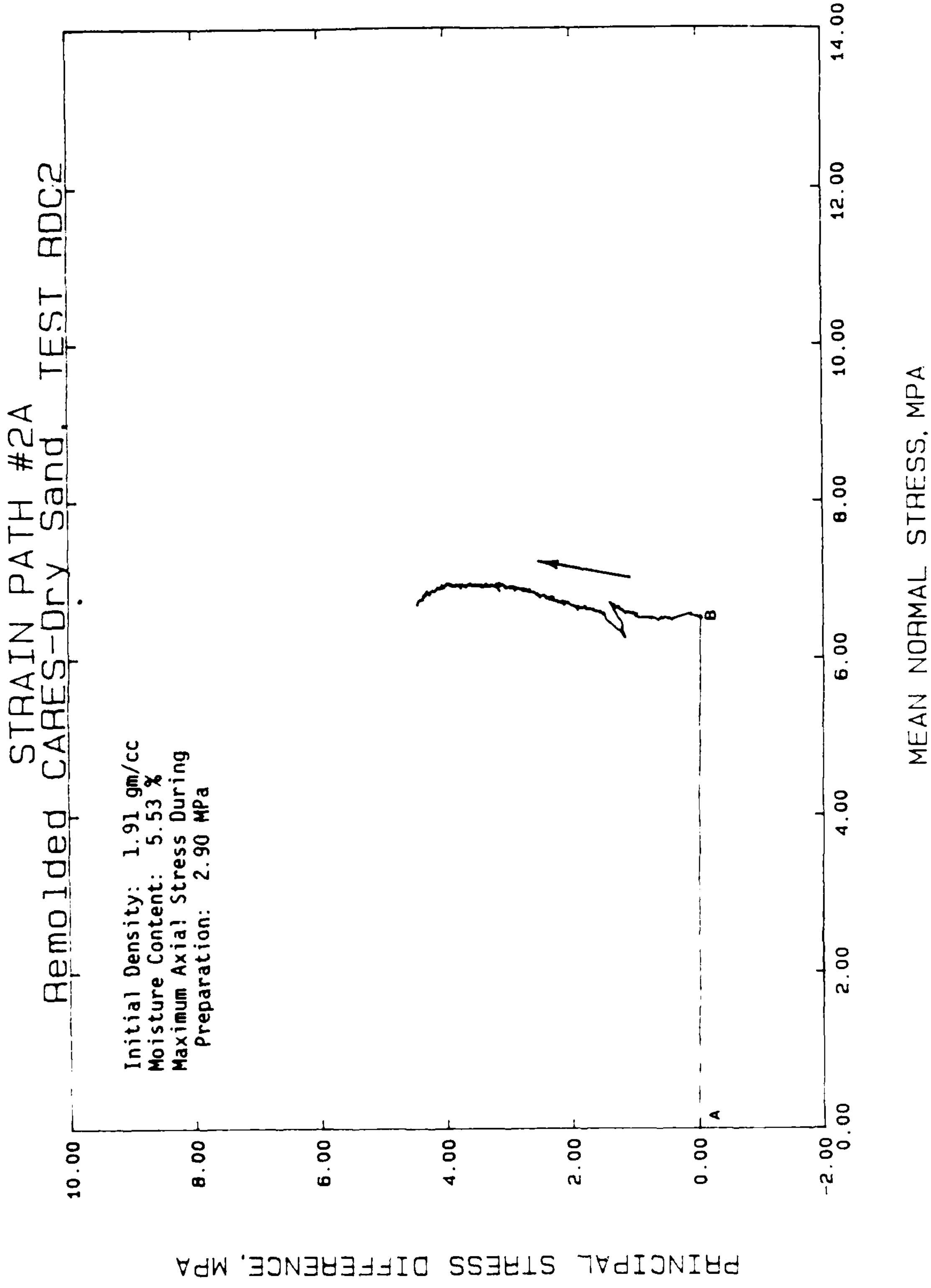

STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.91 gm/cc
Moisture Content: 5.80 %
Maximum Axial Stress During
Preparation: 3.45 MPa
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %

Plate 153



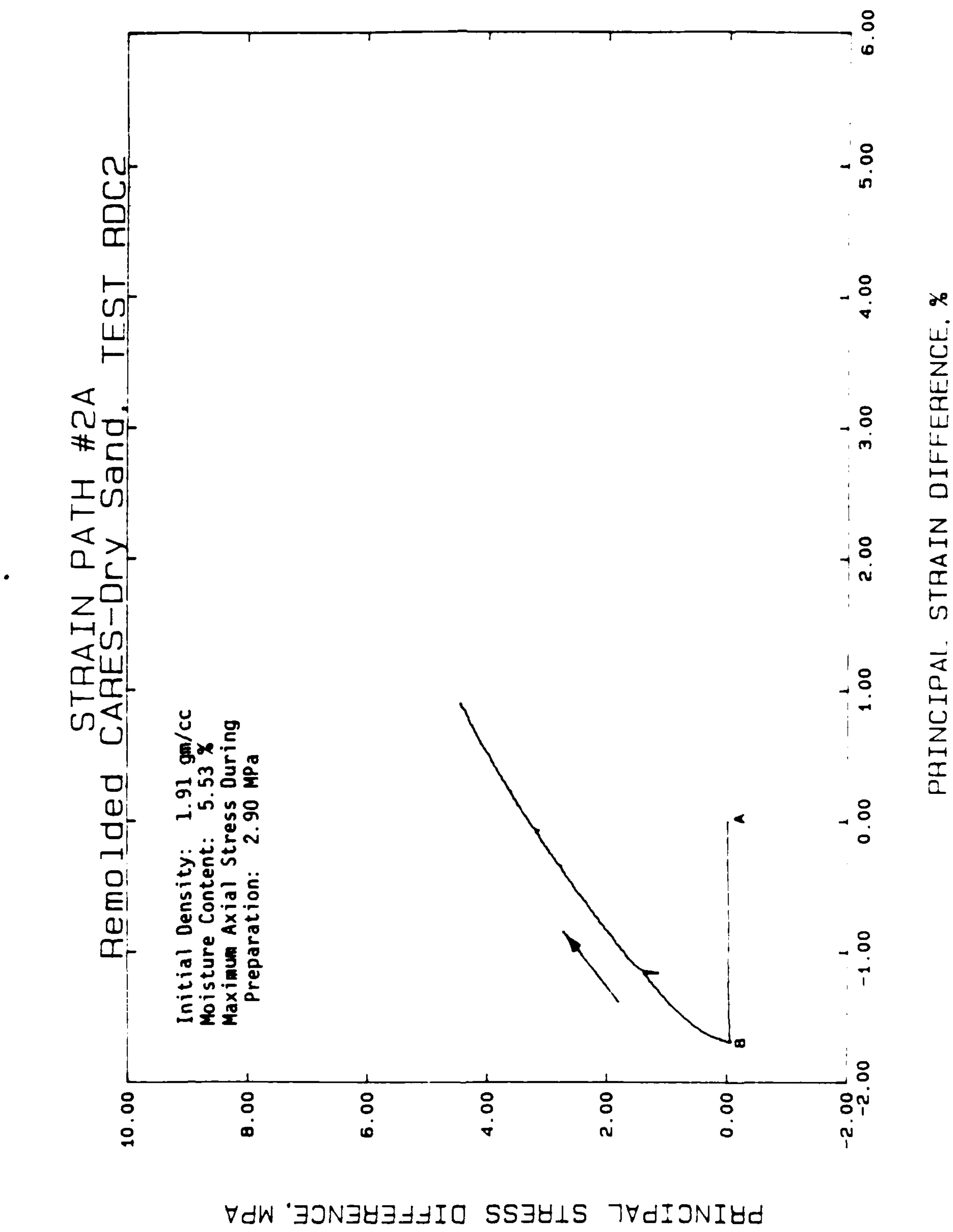
STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.91 gm/cc
Moisture Content: 5.53 %
Maximum Axial Stress During
Preparation: 2.90 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

Plate 154

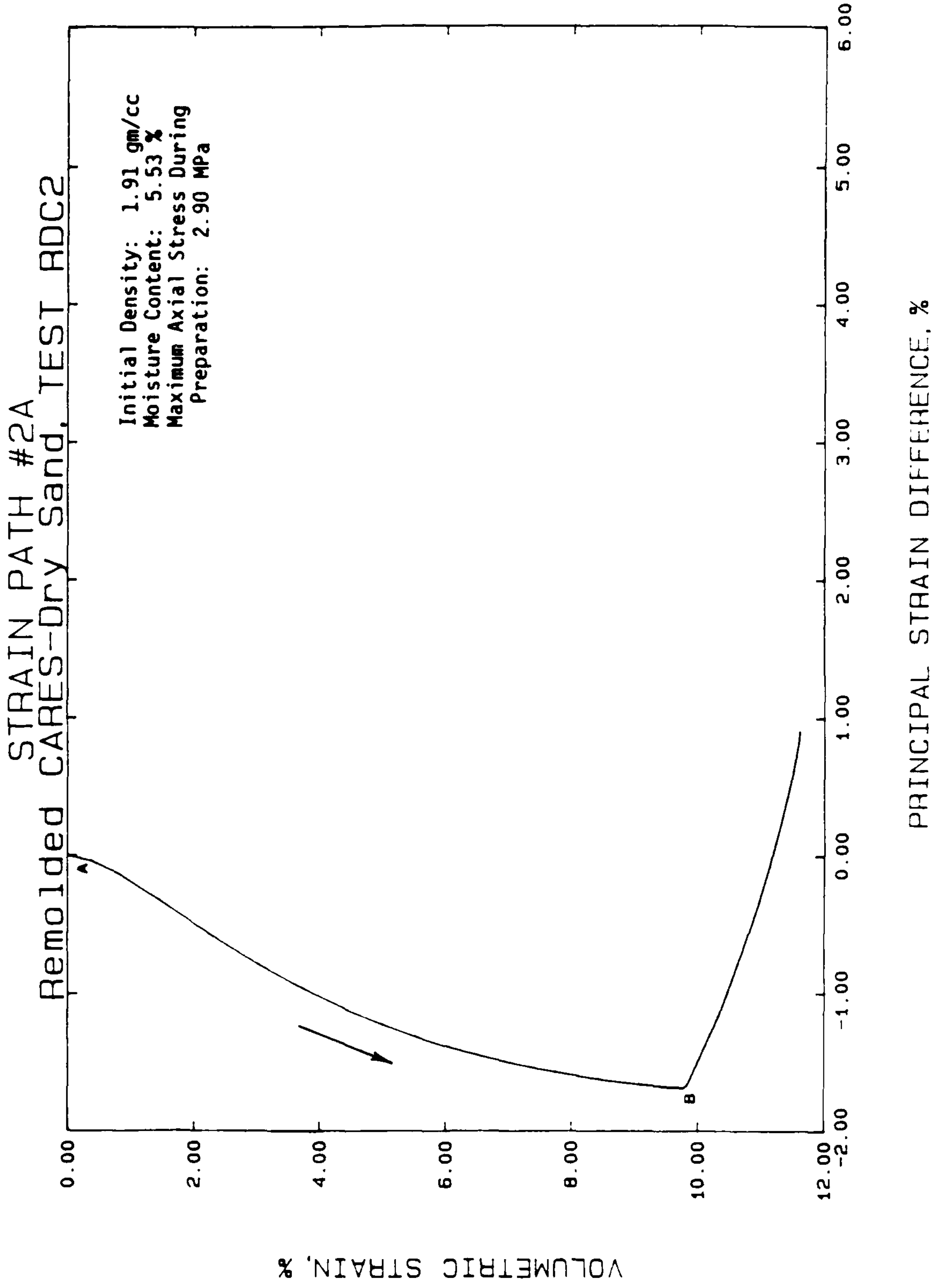


STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.91 gm/cc
Moisture Content: 5.53 %
Maximum Axial Stress During
Preparation: 2.90 MPa
A
B
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA

Plate 155



STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.91 gm/cc
Moisture Content: 5.53 %
Maximum Axial Stress During
Preparation: 2.90 MPa
A
B
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %


STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.91 gm/cc
Moisture Content: 5.53 %
Maximum Axial Stress During
Preparation: 2.90 MPa
A
B
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00

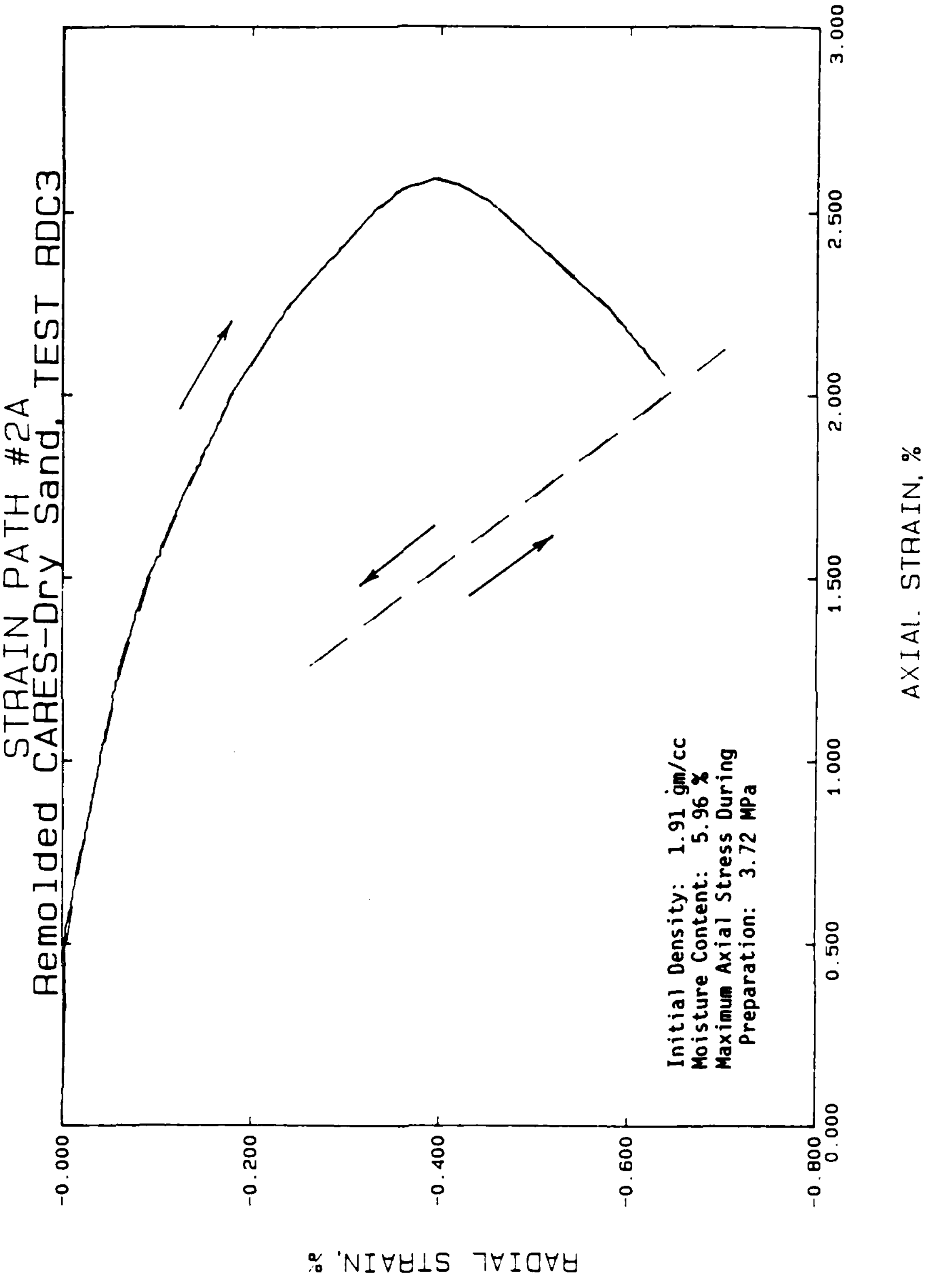
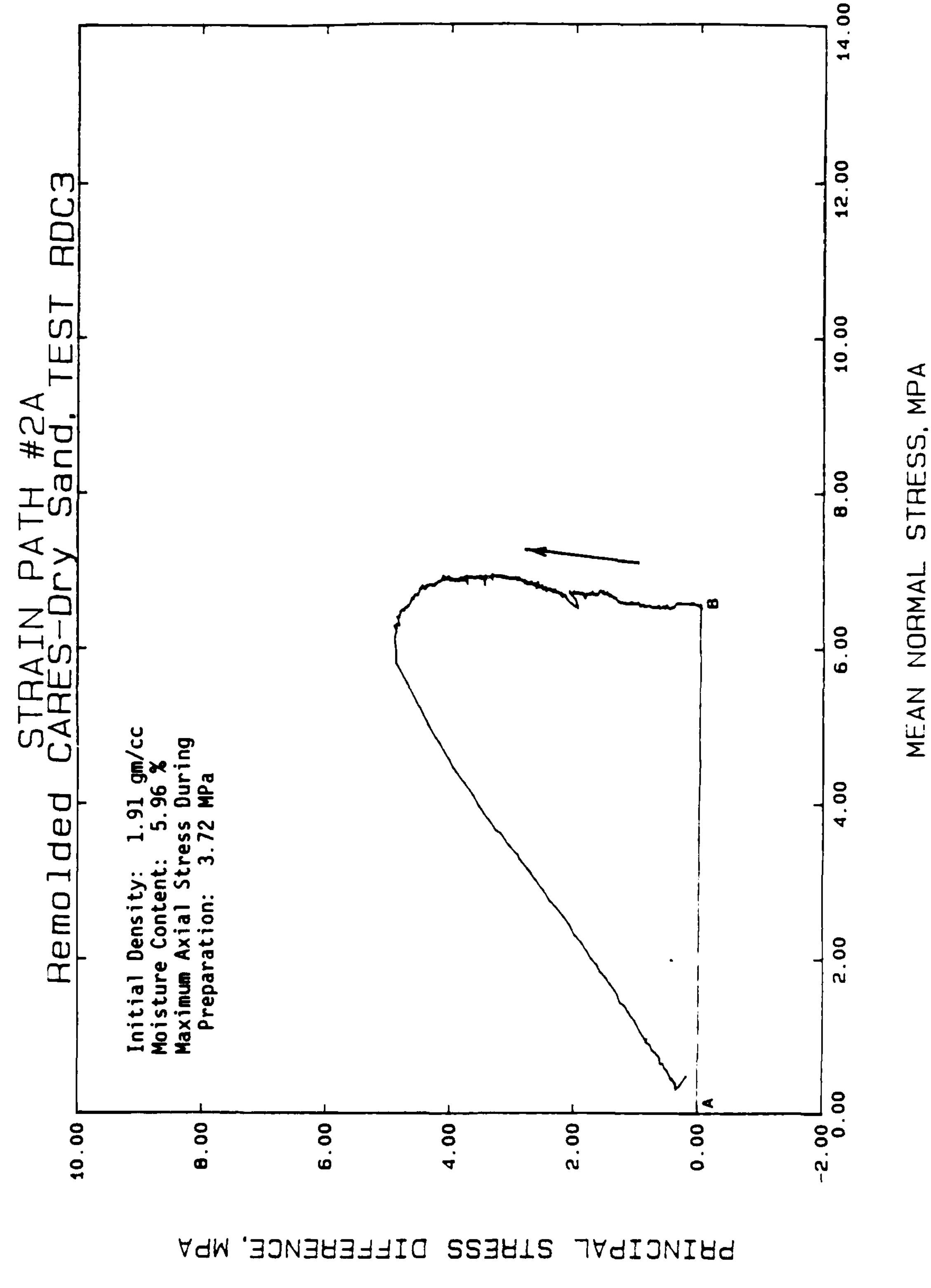
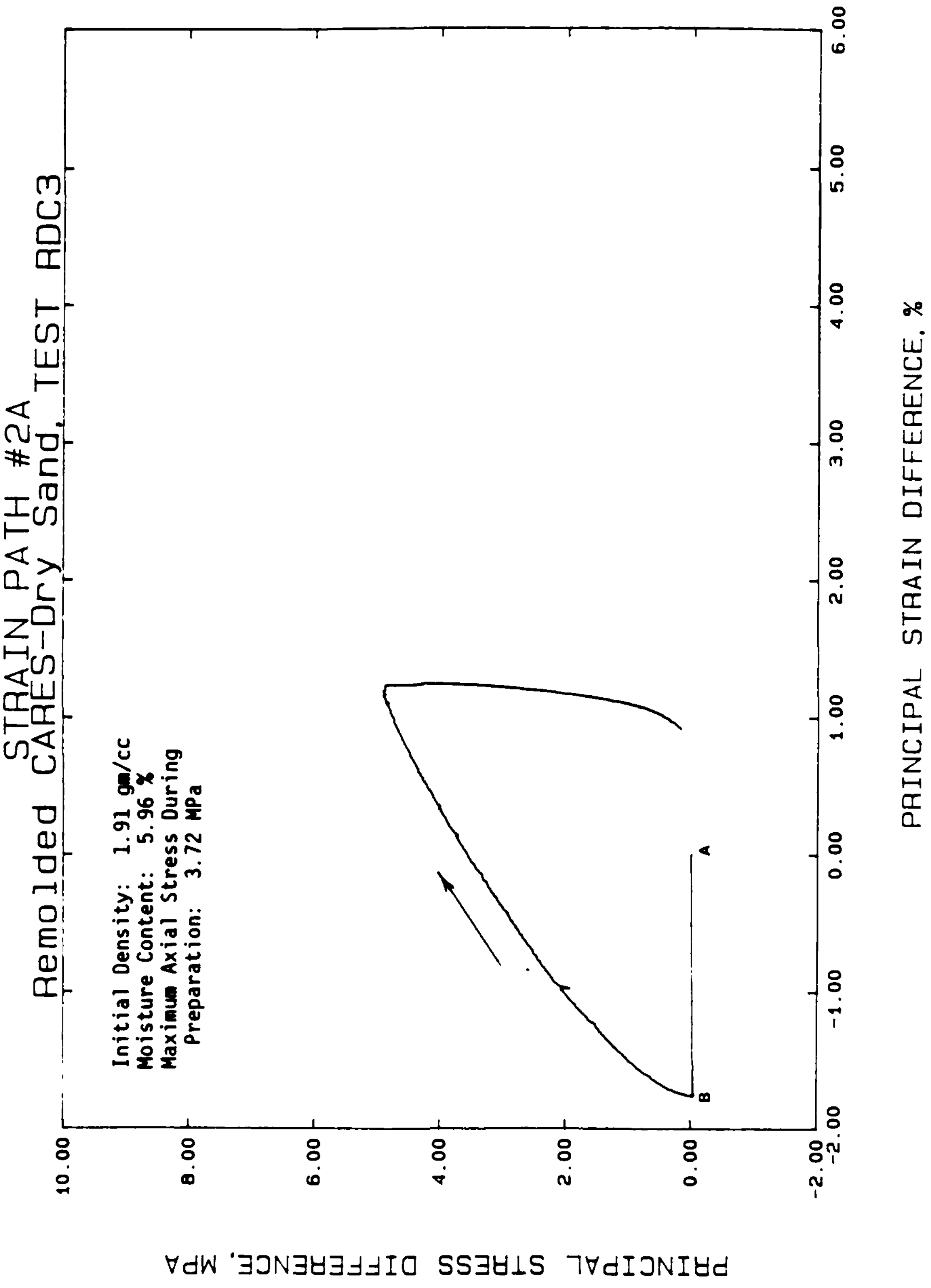

STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.91 gm/cc
Moisture Content: 5.96 %
Maximum Axial Stress During
Preparation: 3.72 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

Plate 158



STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.91 gm/cc
Moisture Content: 5.96 %
Maximum Axial Stress During
Preparation: 3.72 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
MEAN NORMAL STRESS, MPA
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 159


STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.91 gm/cc
Moisture Content: 5.96 %
Maximum Axial Stress During
Preparation: 3.72 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
8.00
10.00

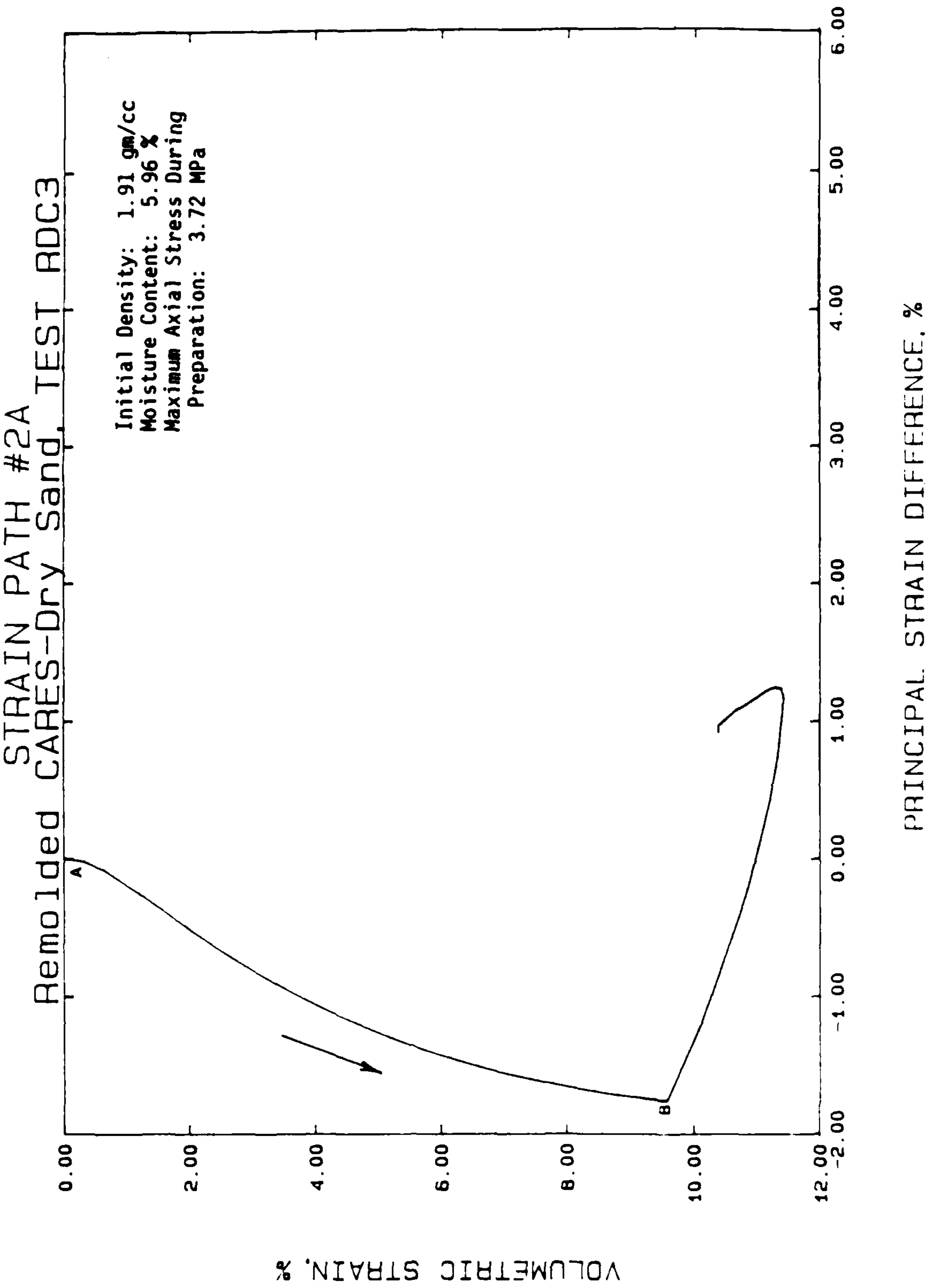
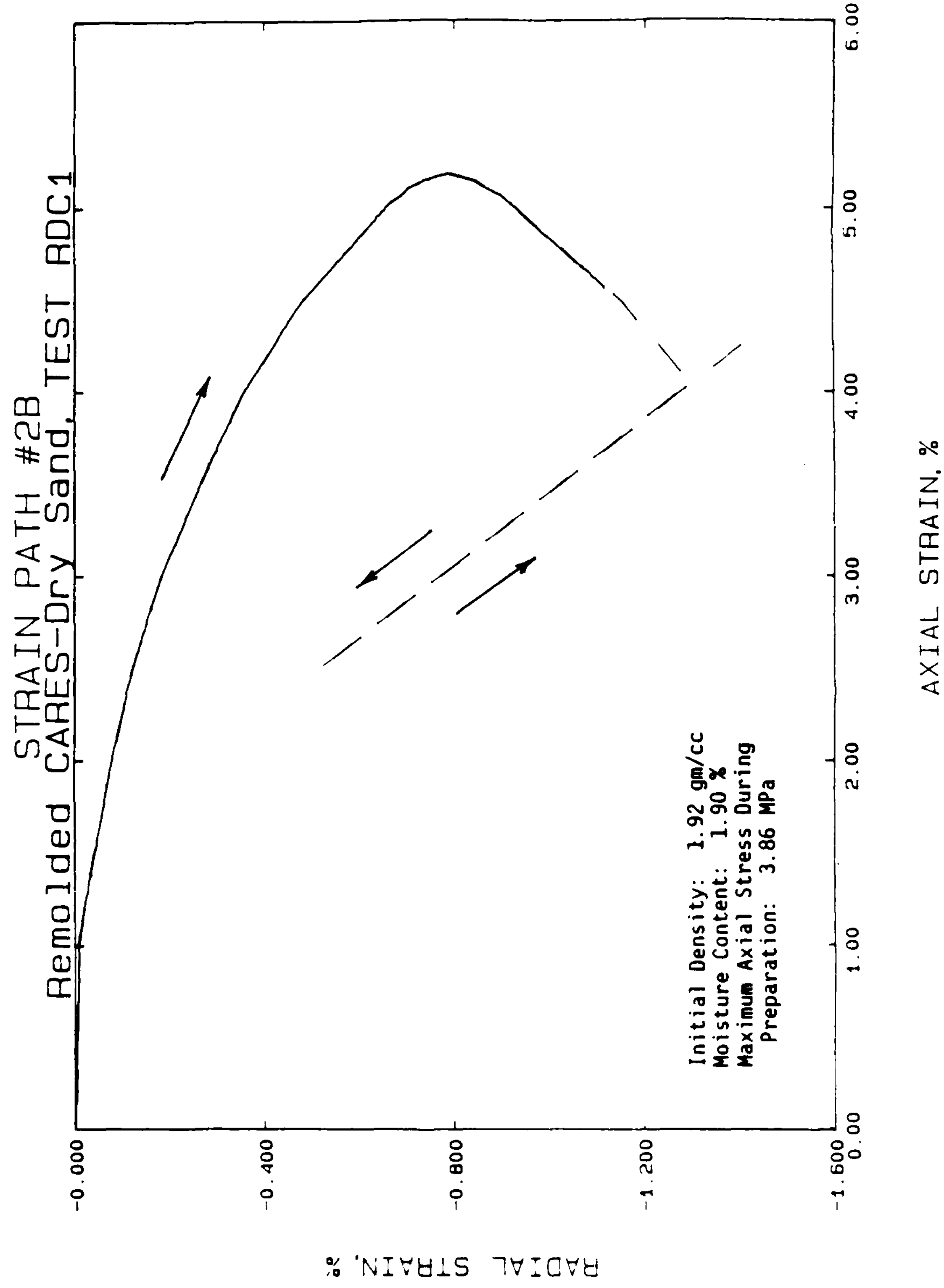
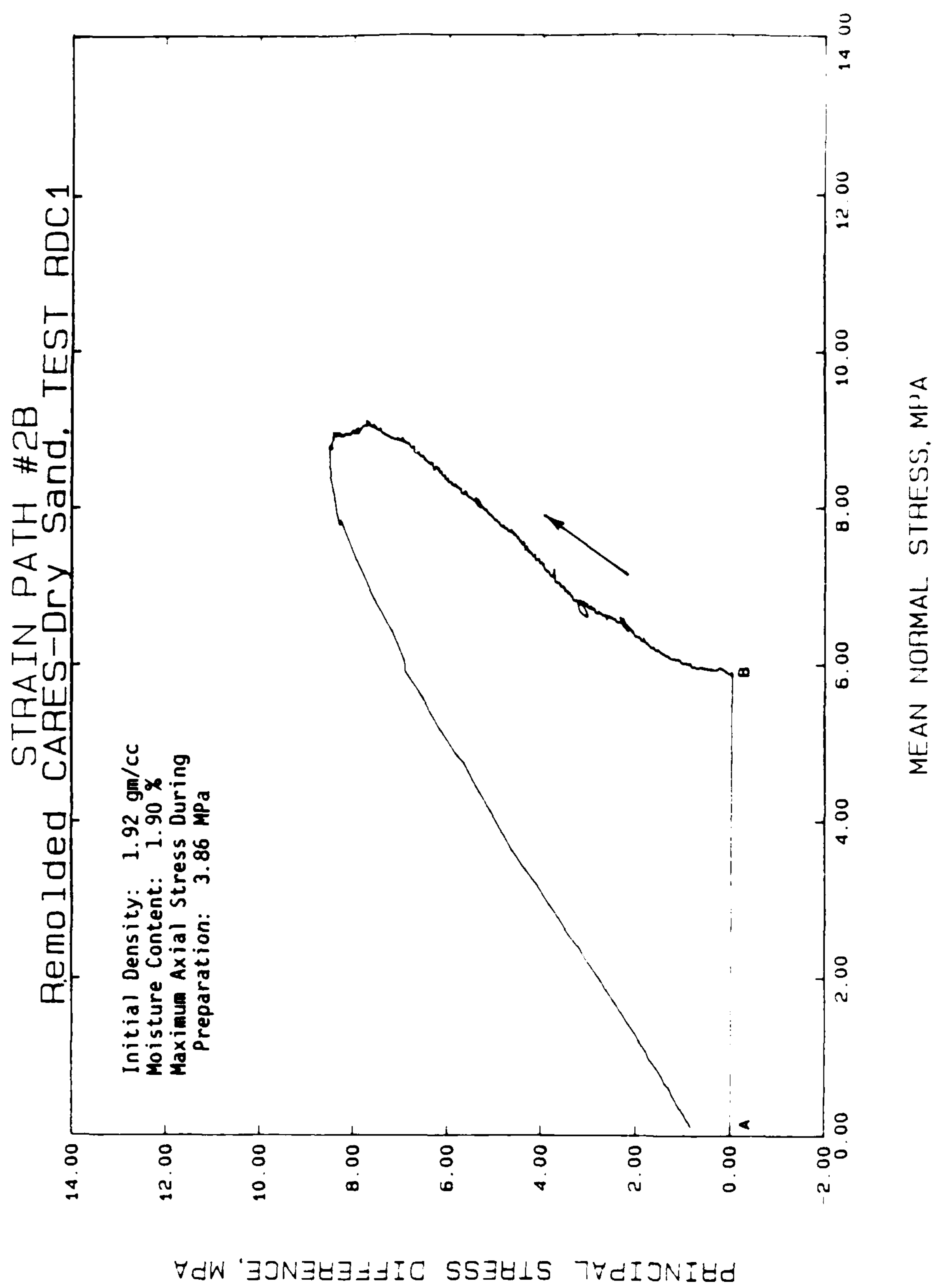
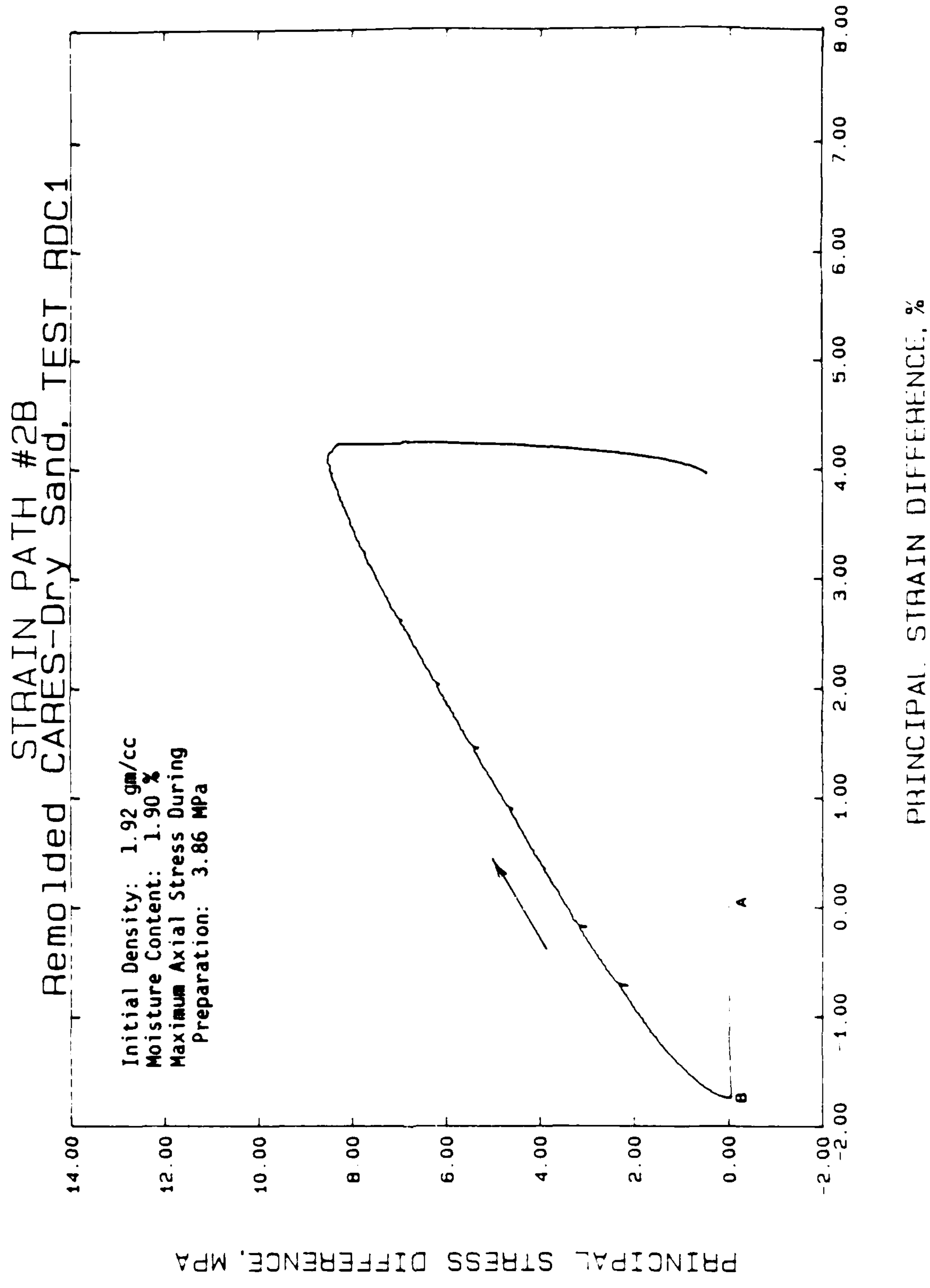

STRAIN PATH #2A
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.91 gm/cc
Moisture Content: 5.96 %
Maximum Axial Stress During
Preparation: 3.72 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00

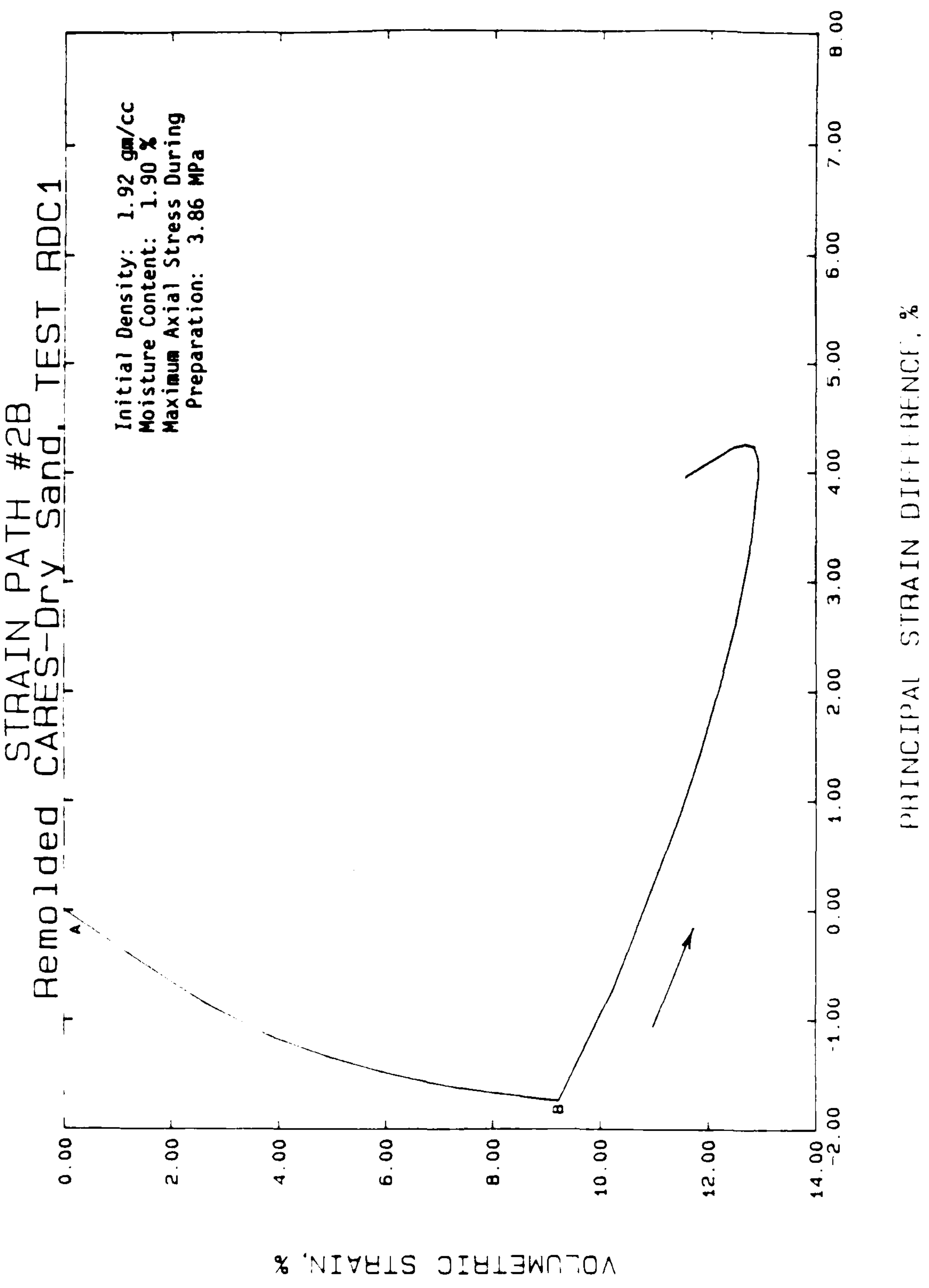
Plate 161



STRAIN PATH #2B
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.92 gm/cc
Moisture Content: 1.90 %
Maximum Axial Stress During
Preparation: 3.86 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
-0.000
-0.400
-0.800
-1.200
-1.600


STRAIN PATH #2B
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.92 gm/cc
Moisture Content: 1.90 %
Maximum Axial Stress During
Preparation: 3.86 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00


STRAIN PATH #2B
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.92 gm/cc
Moisture Content: 1.90 %
Maximum Axial Stress During
Preparation: 3.86 MPa
A
B
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRESS DIFFERENCE, MPA



STRAIN PATH #2B
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.92 gm/cc
Moisture Content: 1.90 %
Maximum Axial Stress During
Preparation: 3.86 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 165

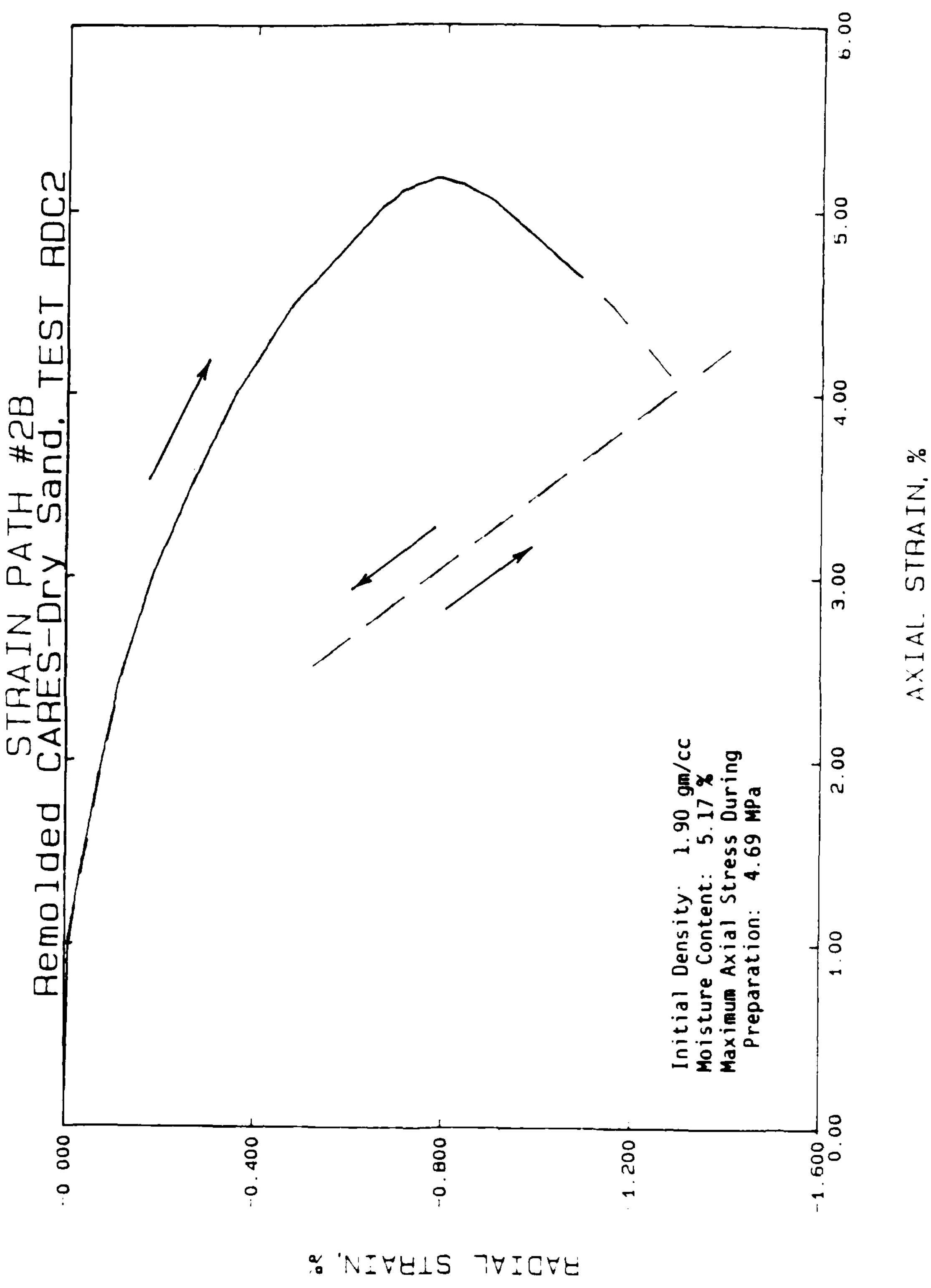

STRAIN PATH #2B
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.90 gm/cc
Moisture Content: 5.17 %
Maximum Axial Stress During
Preparation: 4.69 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
-0.000
-0.400
-0.800
-1.200
-1.600

Plate 166

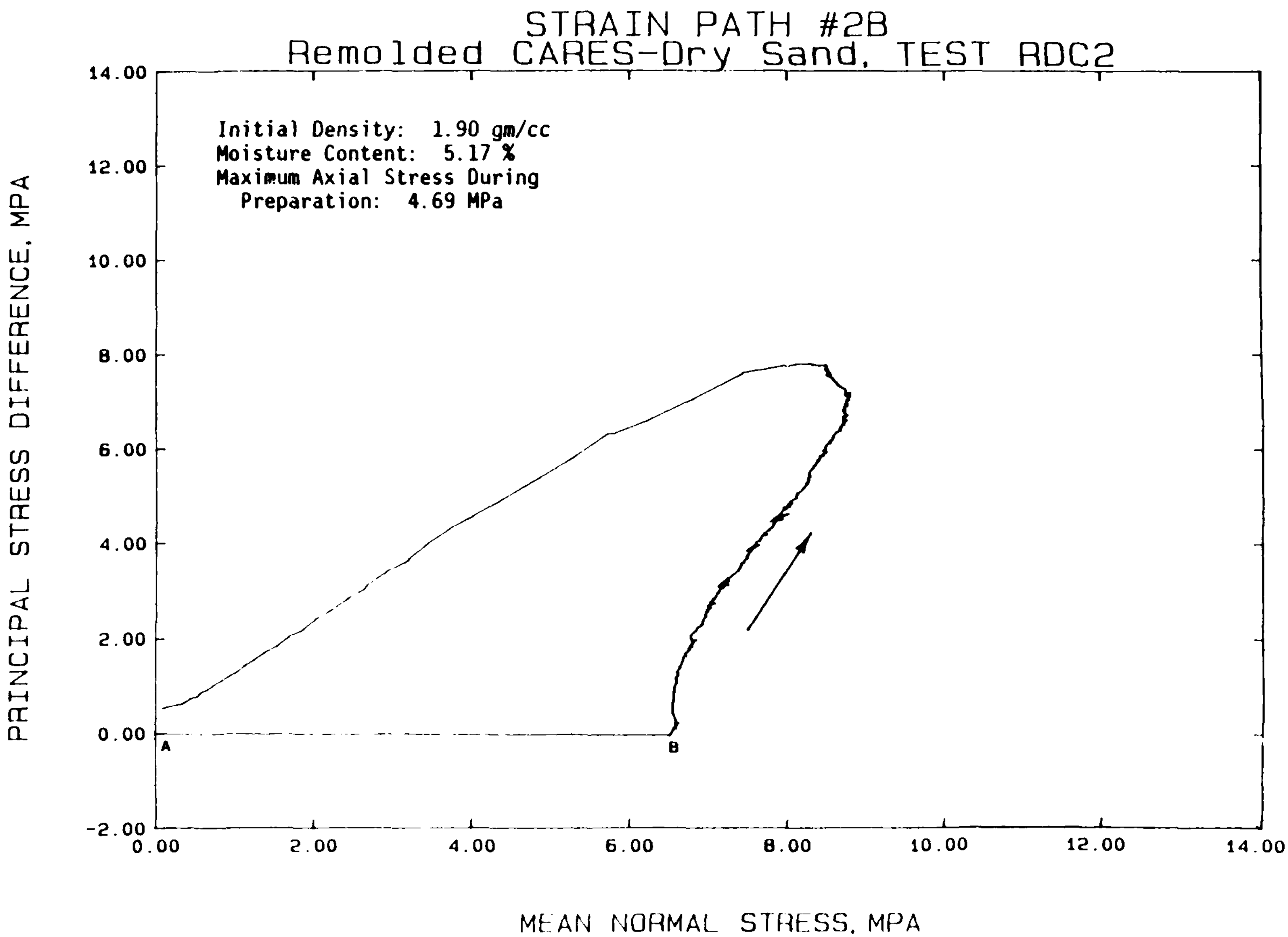

STRAIN PATH #2B
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.90 gm/cc
Moisture Content: 5.17 %
Maximum Axial Stress During
Preparation: 4.69 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00

Plate 167

STRAIN PATH #2B
Remolded CARES-Dry Sand, TEST RDC2

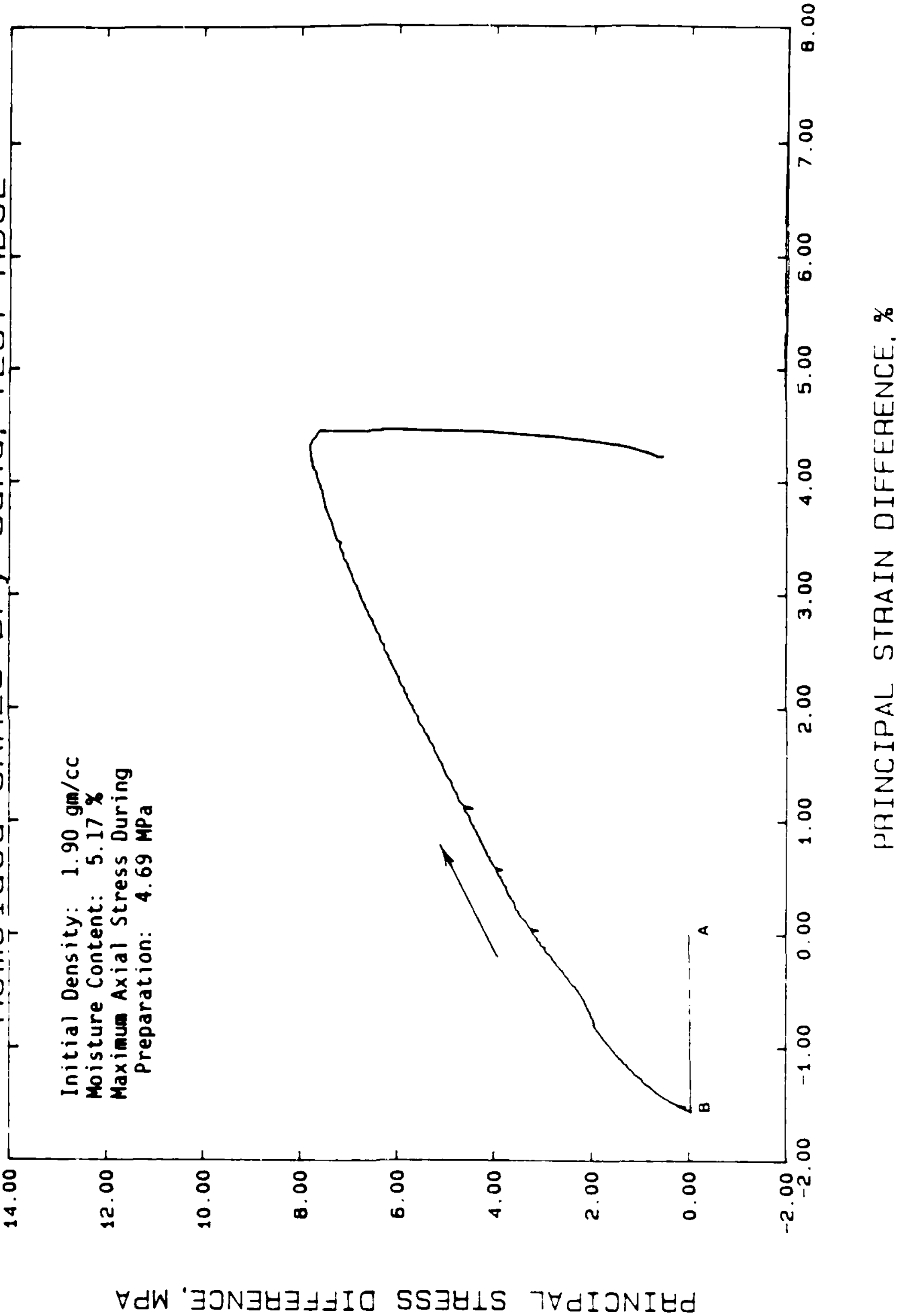


Plate 168

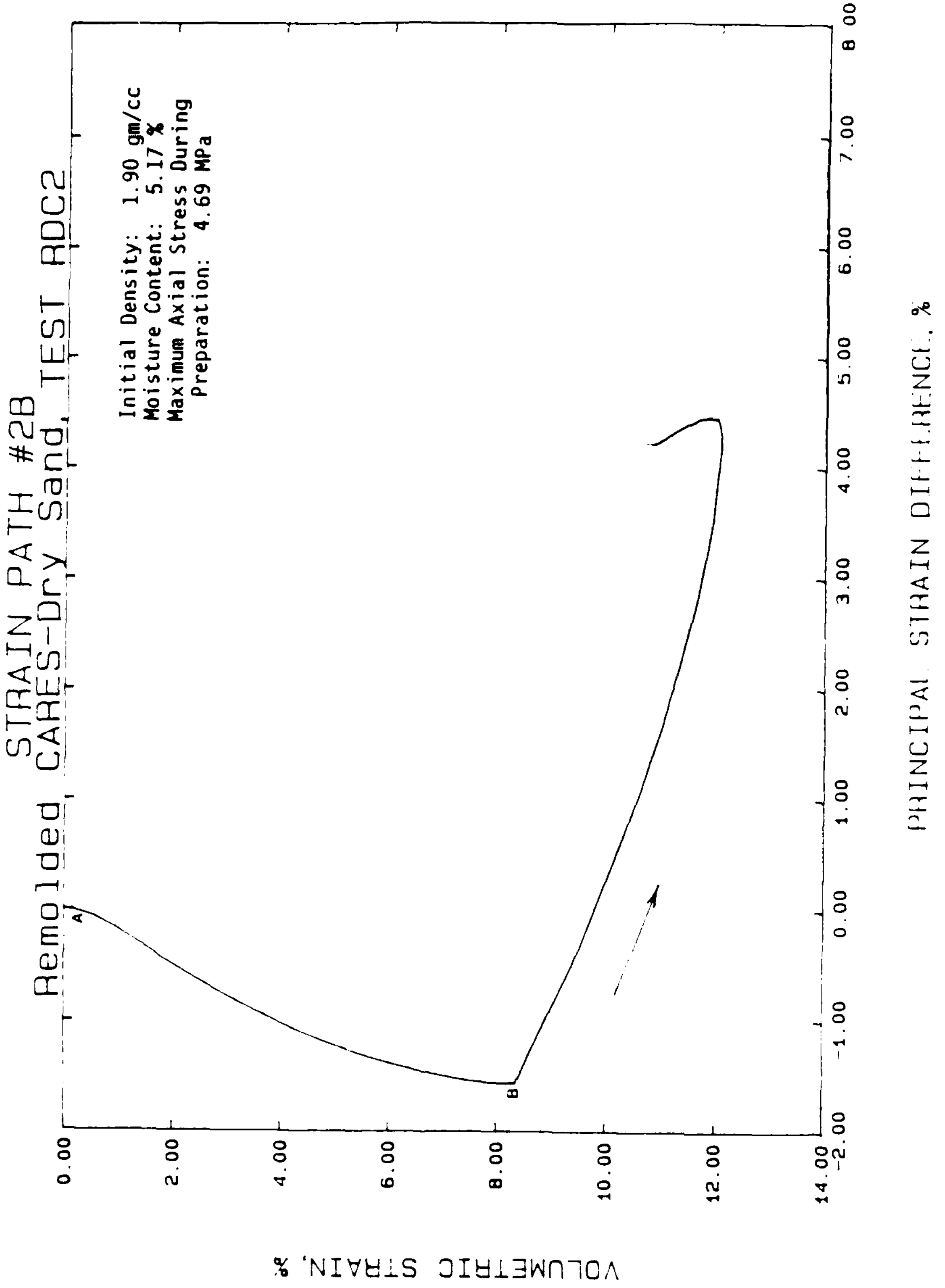

STRAIN PATH #2B
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.90 gm/cc
Moisture Content: 5.17 %
Maximum Axial Stress During
Preparation: 4.69 MPa
A
B
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00

Plate 169

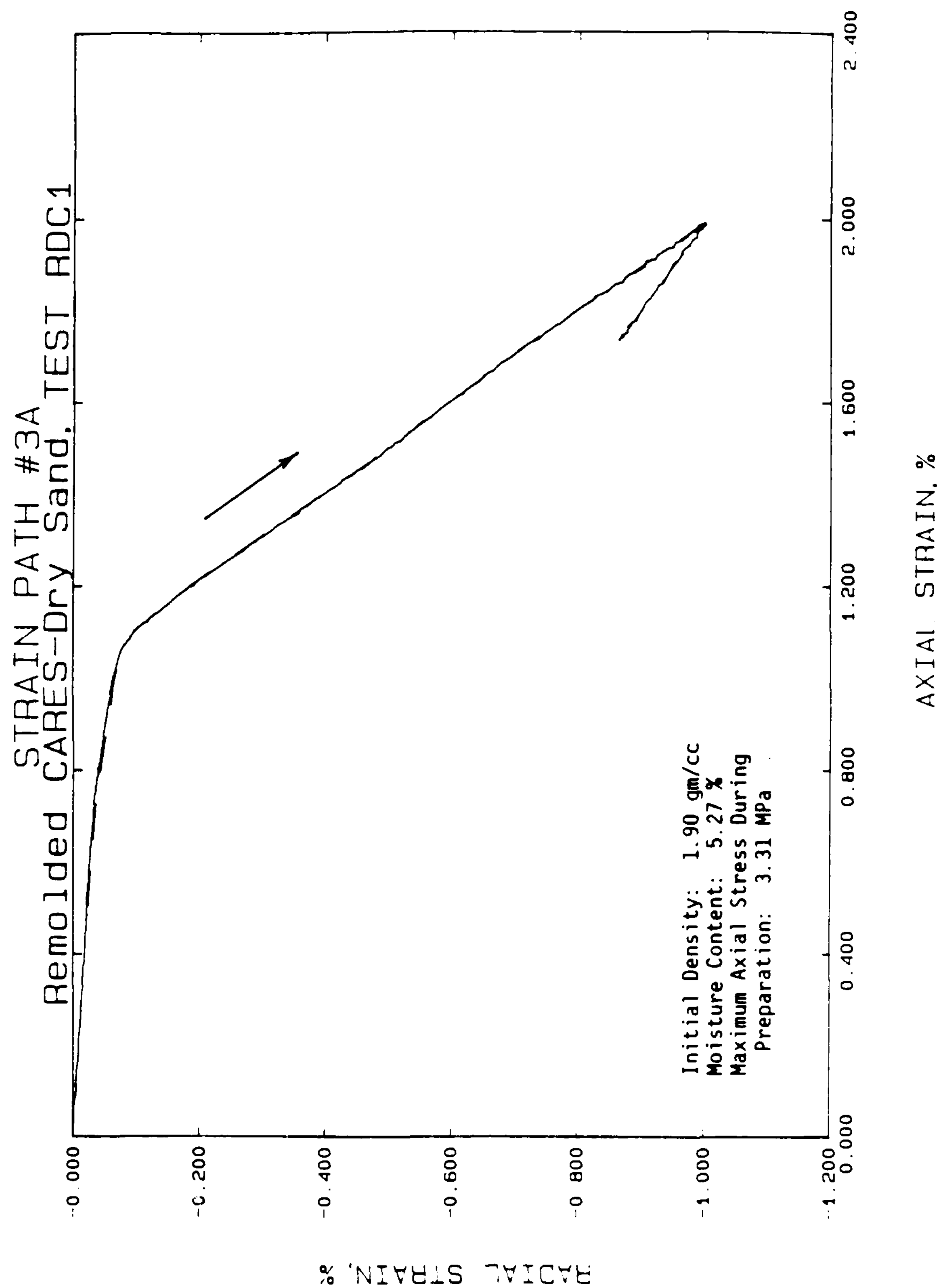

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.90 gm/cc
Moisture Content: 5.27 %
Maximum Axial Stress During
Preparation: 3.31 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200

Plate 170

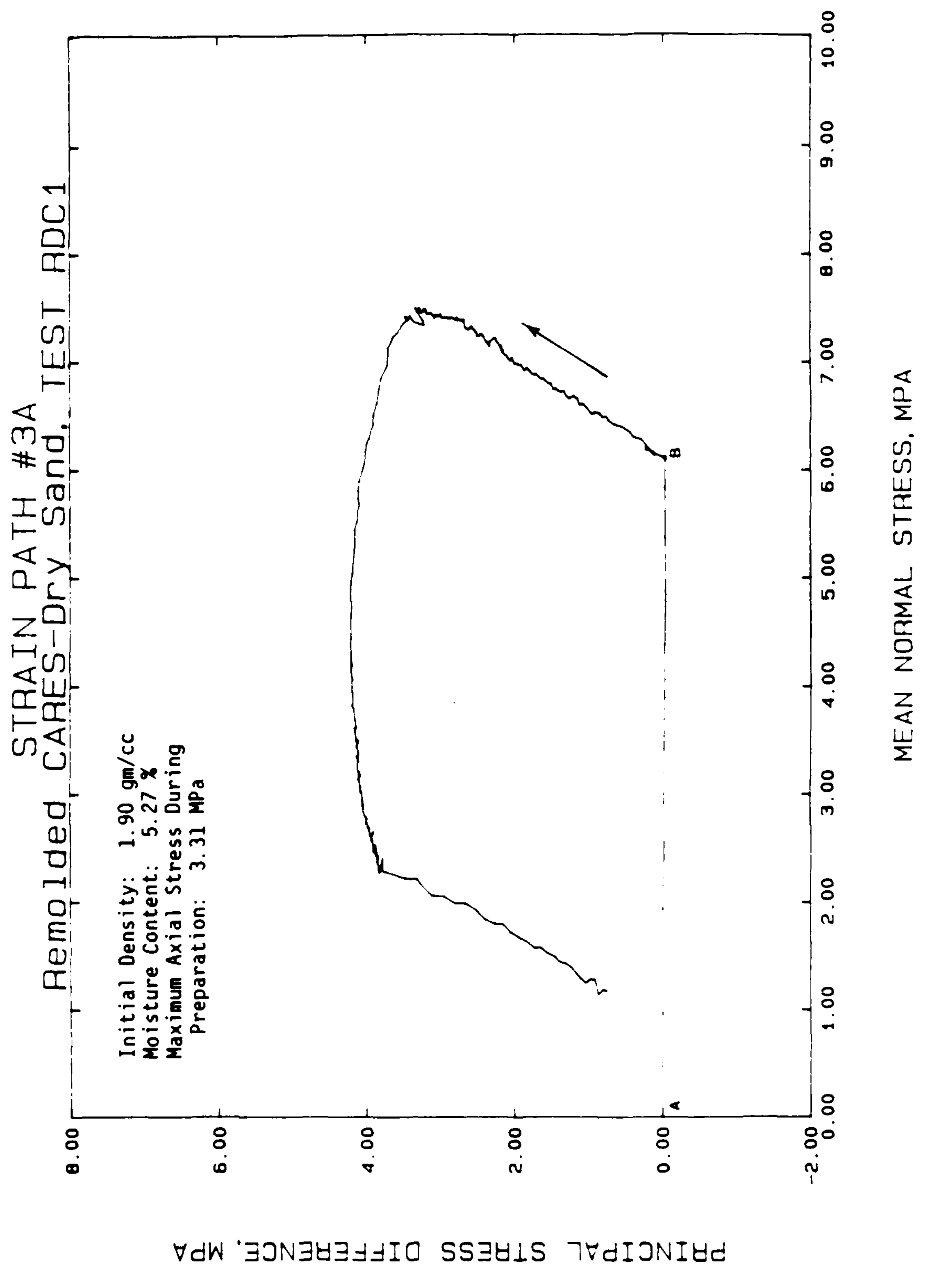
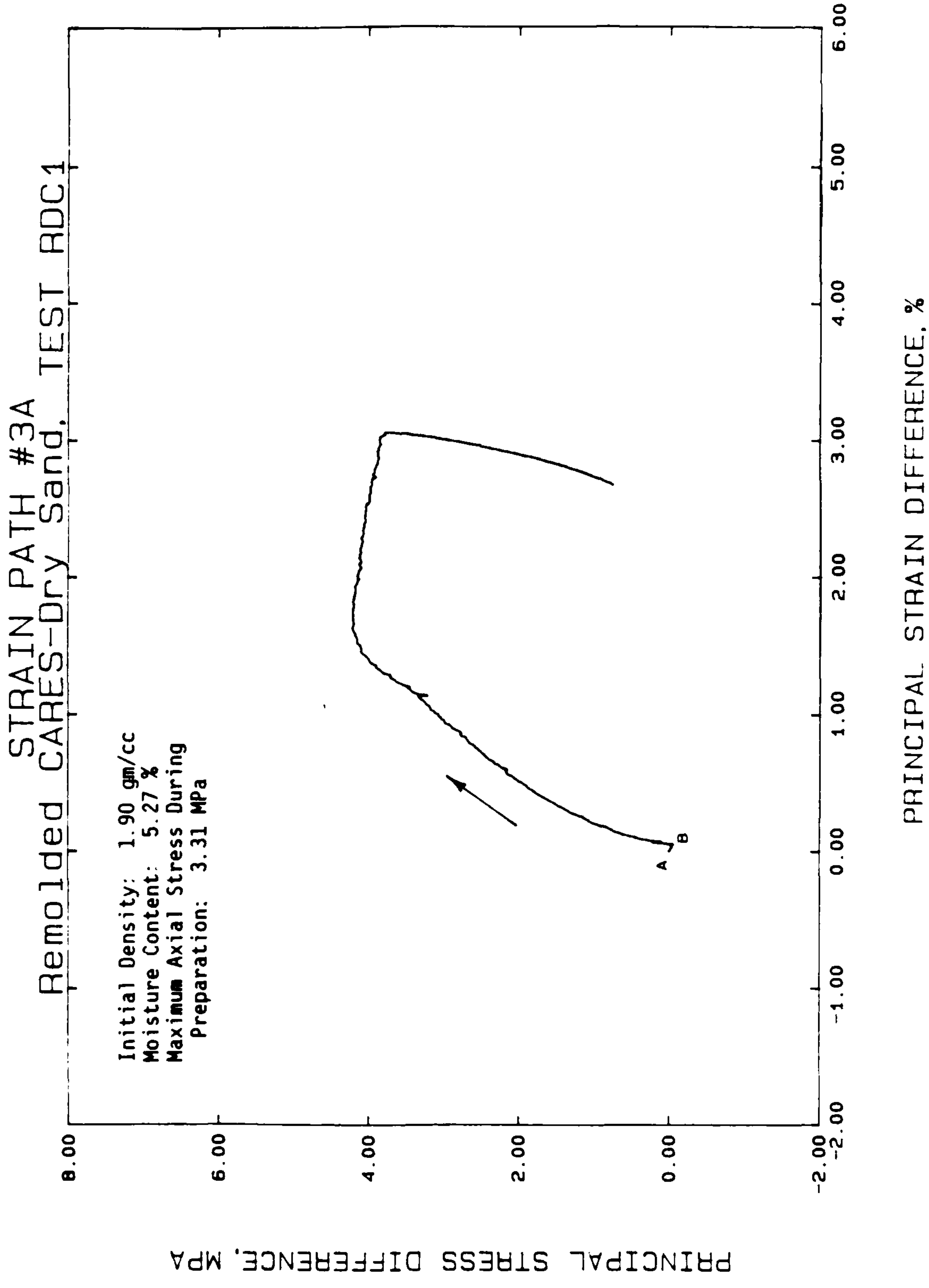

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.90 gm/cc
Moisture Content: 5.27 %
Maximum Axial Stress During
Preparation: 3.31 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
A
B

Plate 171


STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.90 gm/cc
Moisture Content: 5.27 %
Maximum Axial Stress During
Preparation: 3.31 MPa
A
B
8.00
6.00
4.00
2.00
0.00
-2.00
-1.00
1.00
3.00
5.00
6.00
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %

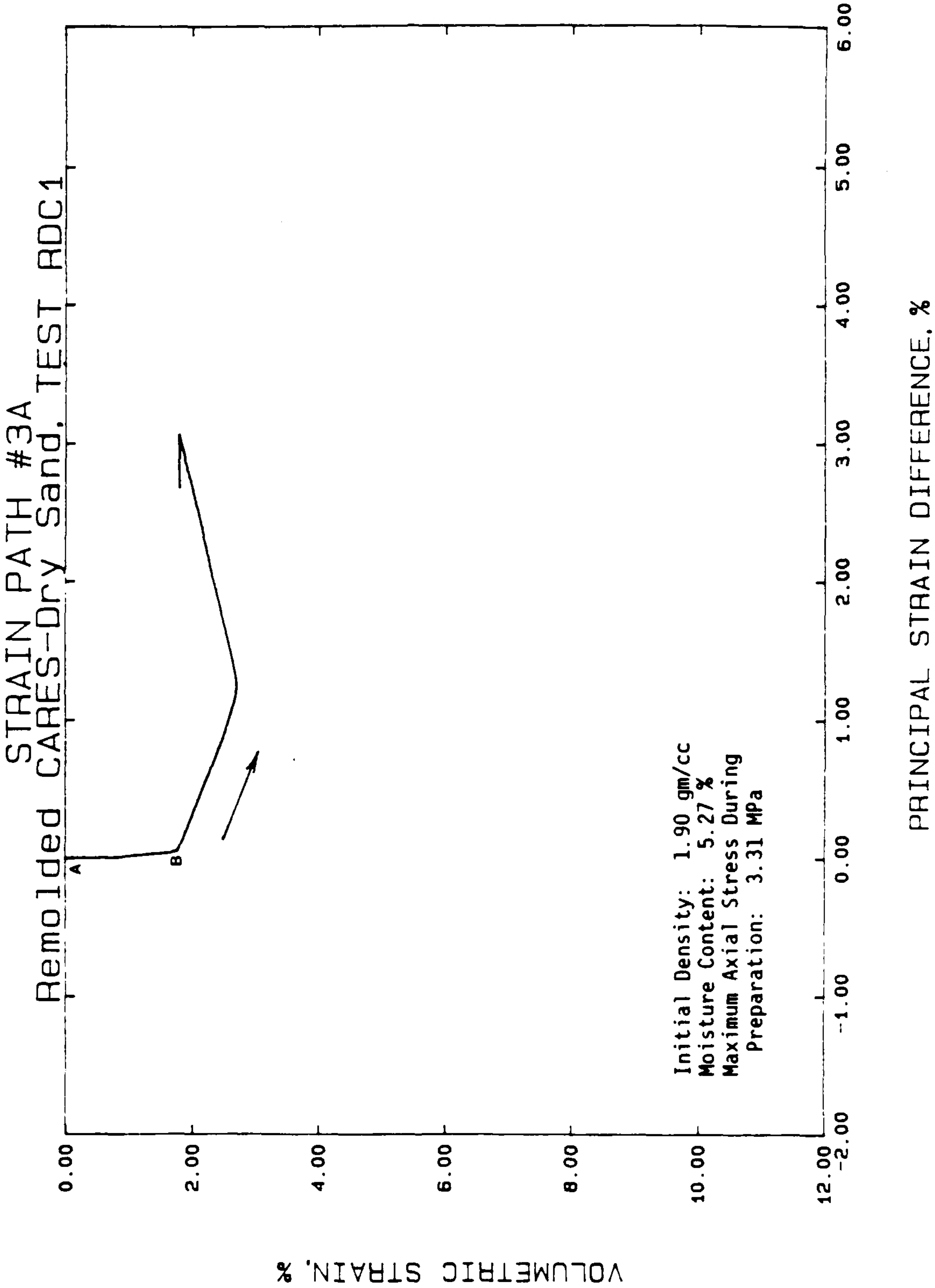

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC1
A
B
Initial Density: 1.90 gm/cc
Moisture Content: 5.27 %
Maximum Axial Stress During
Preparation: 3.31 MPa
0.00
2.00
4.00
6.00
8.00
10.00
12.00
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %

Plate 173

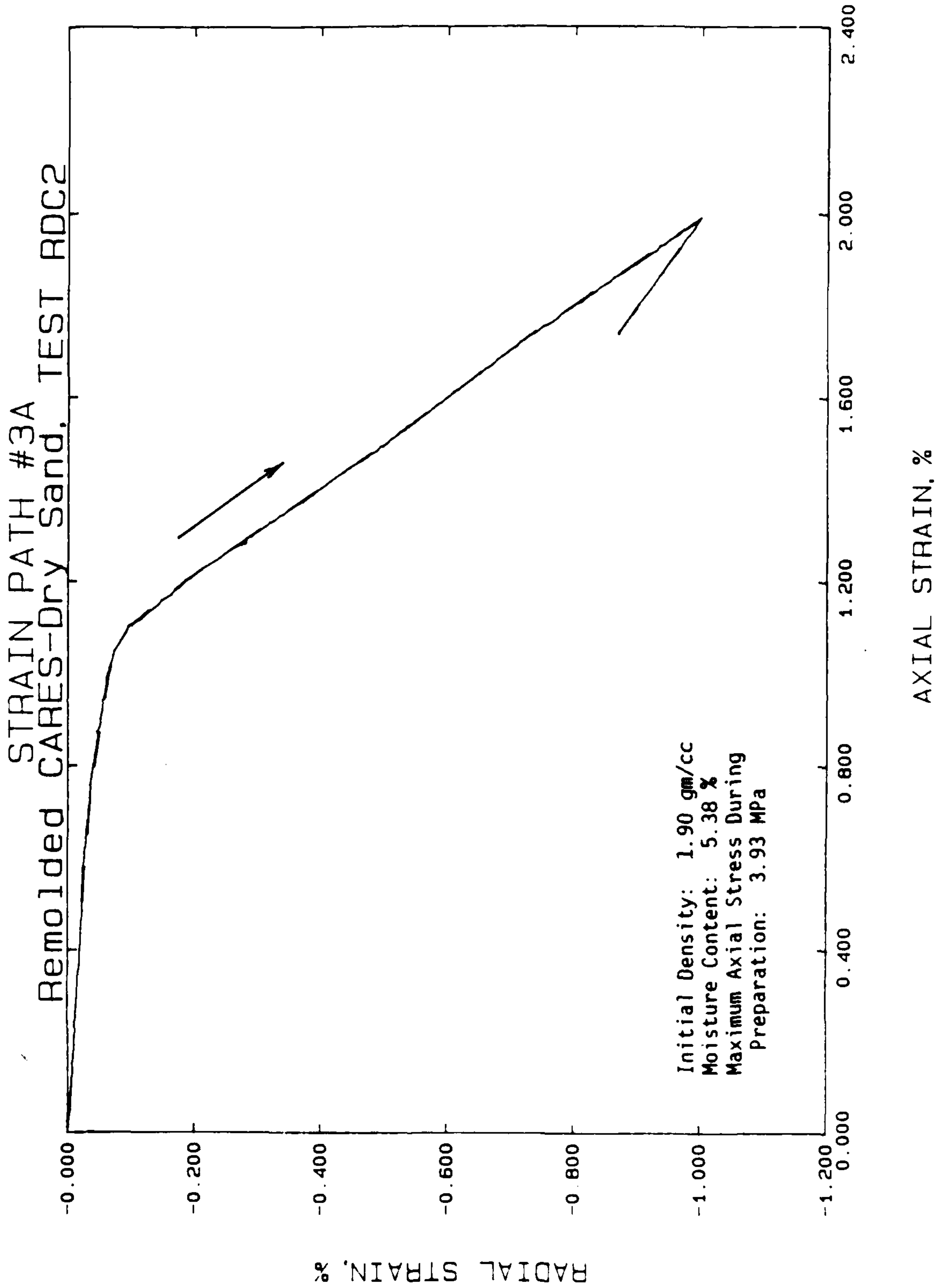

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.90 gm/cc
Moisture Content: 5.38 %
Maximum Axial Stress During
Preparation: 3.93 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200

Plate 174

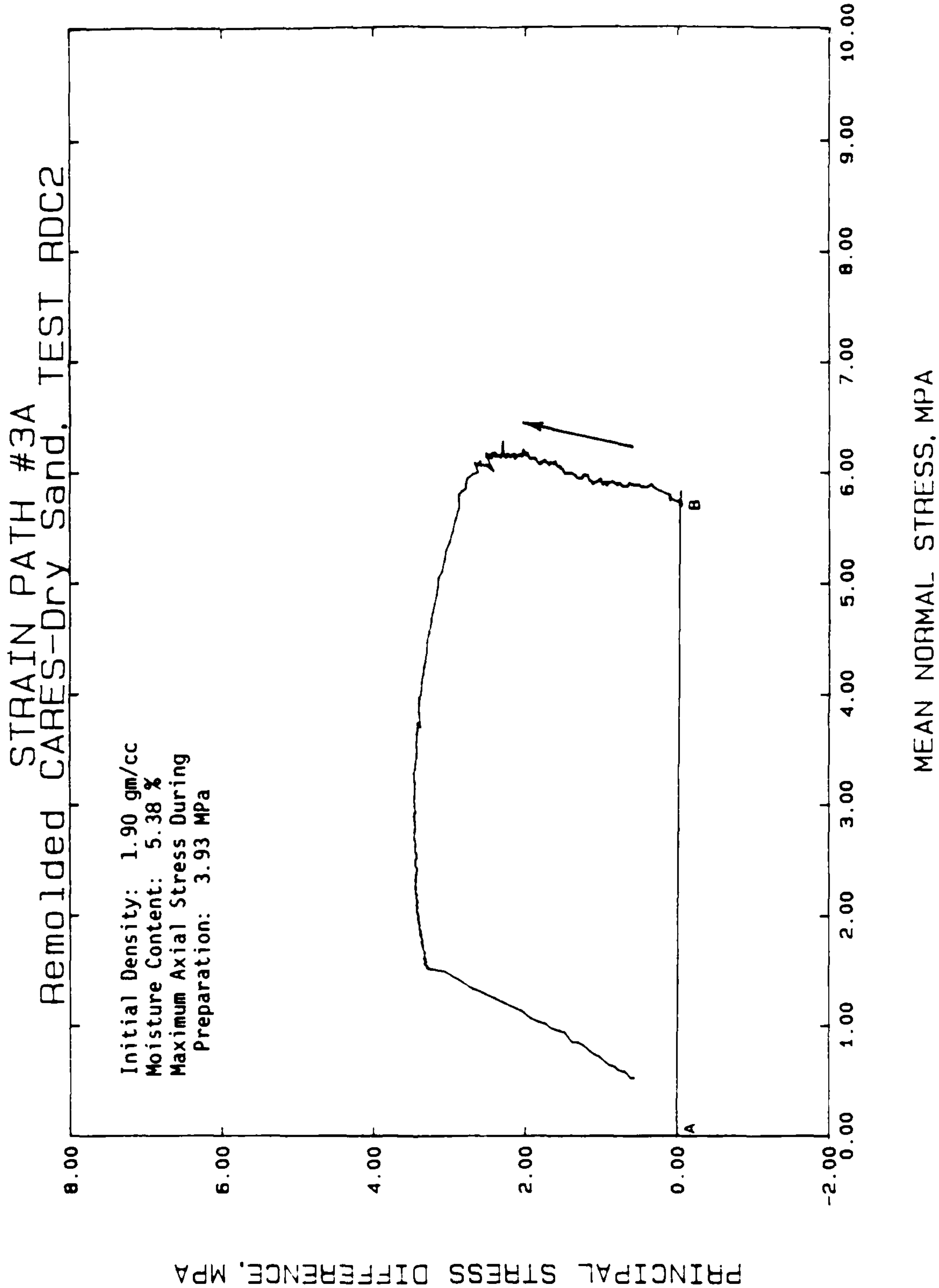

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.90 gm/cc
Moisture Content: 5.38 %
Maximum Axial Stress During
Preparation: 3.93 MPa
A
B
-2.00
0.00
2.00
4.00
6.00
8.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
MEAN NORMAL STRESS, MPA
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 175

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC2

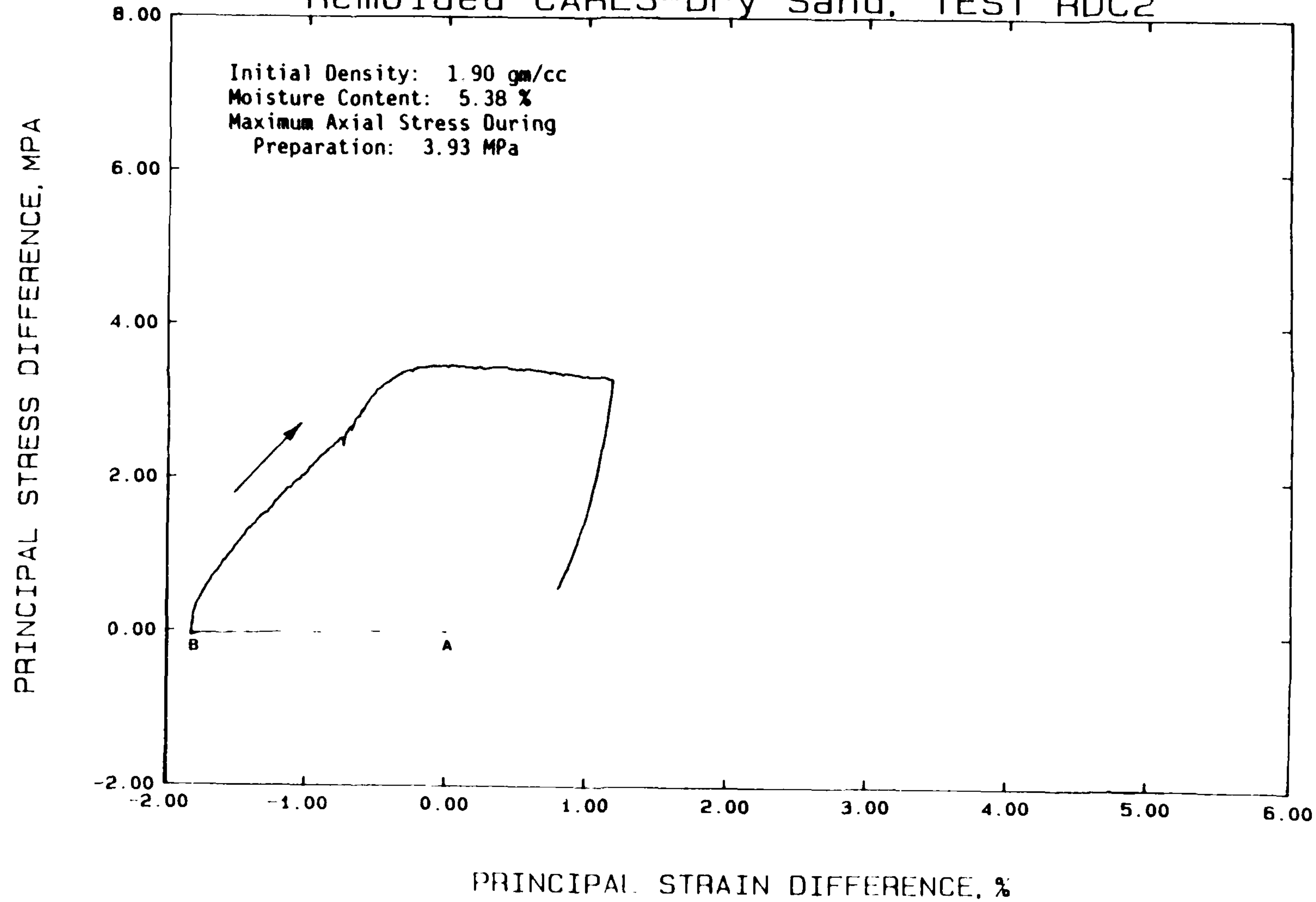


Plate 176

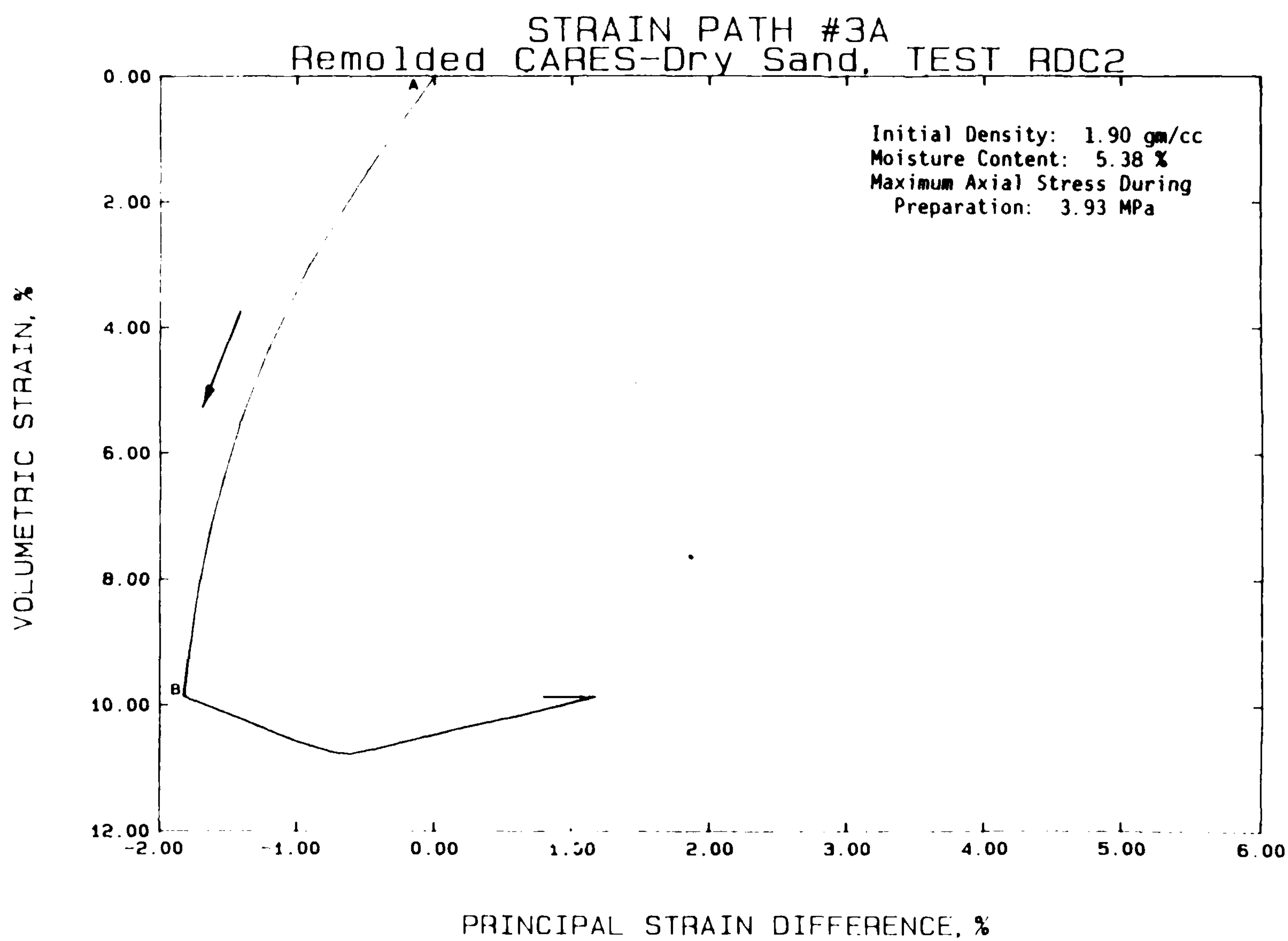
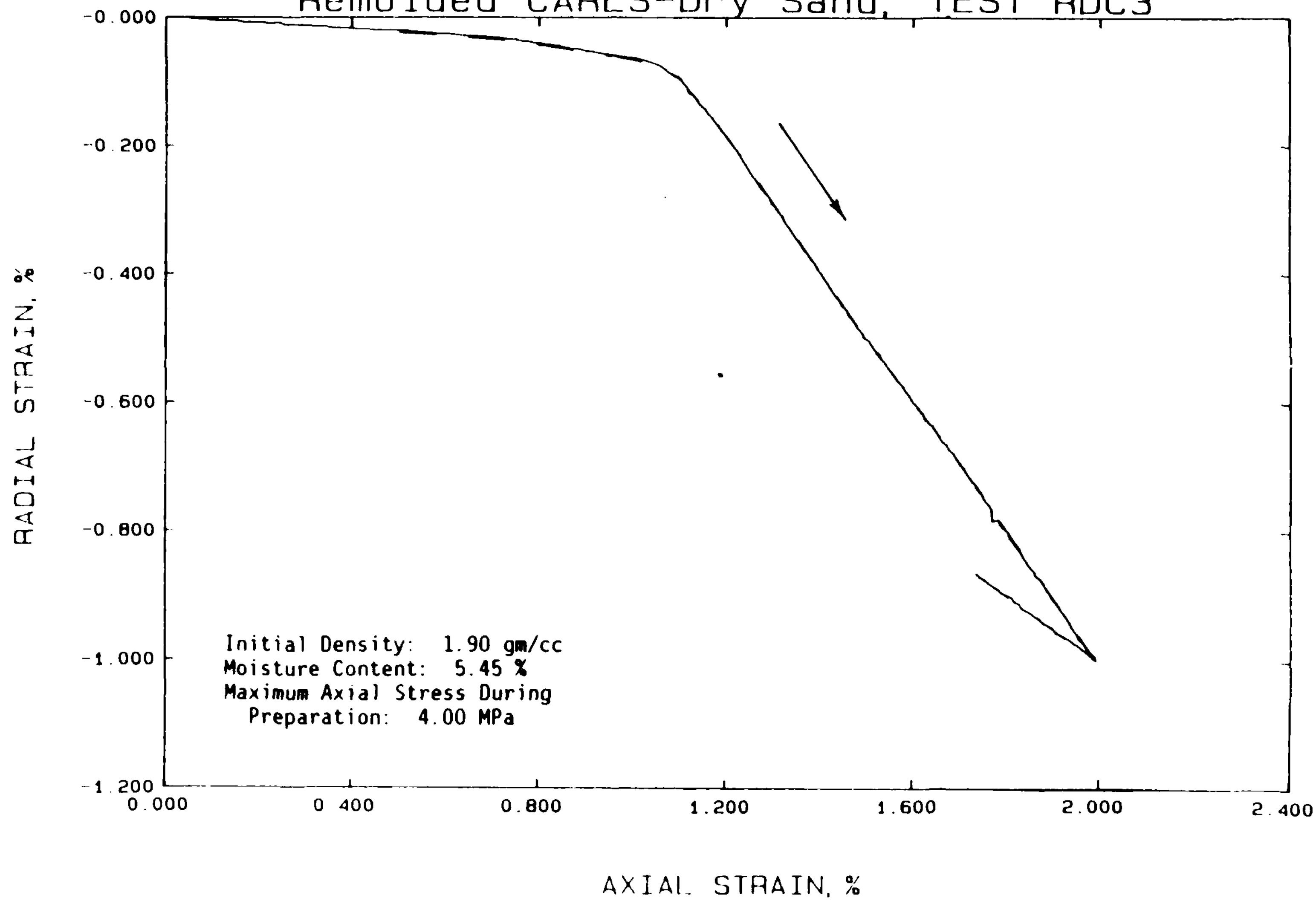

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.90 gm/cc
Moisture Content: 5.38 %
Maximum Axial Stress During
Preparation: 3.93 MPa
A
B
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %

Plate 177

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC3



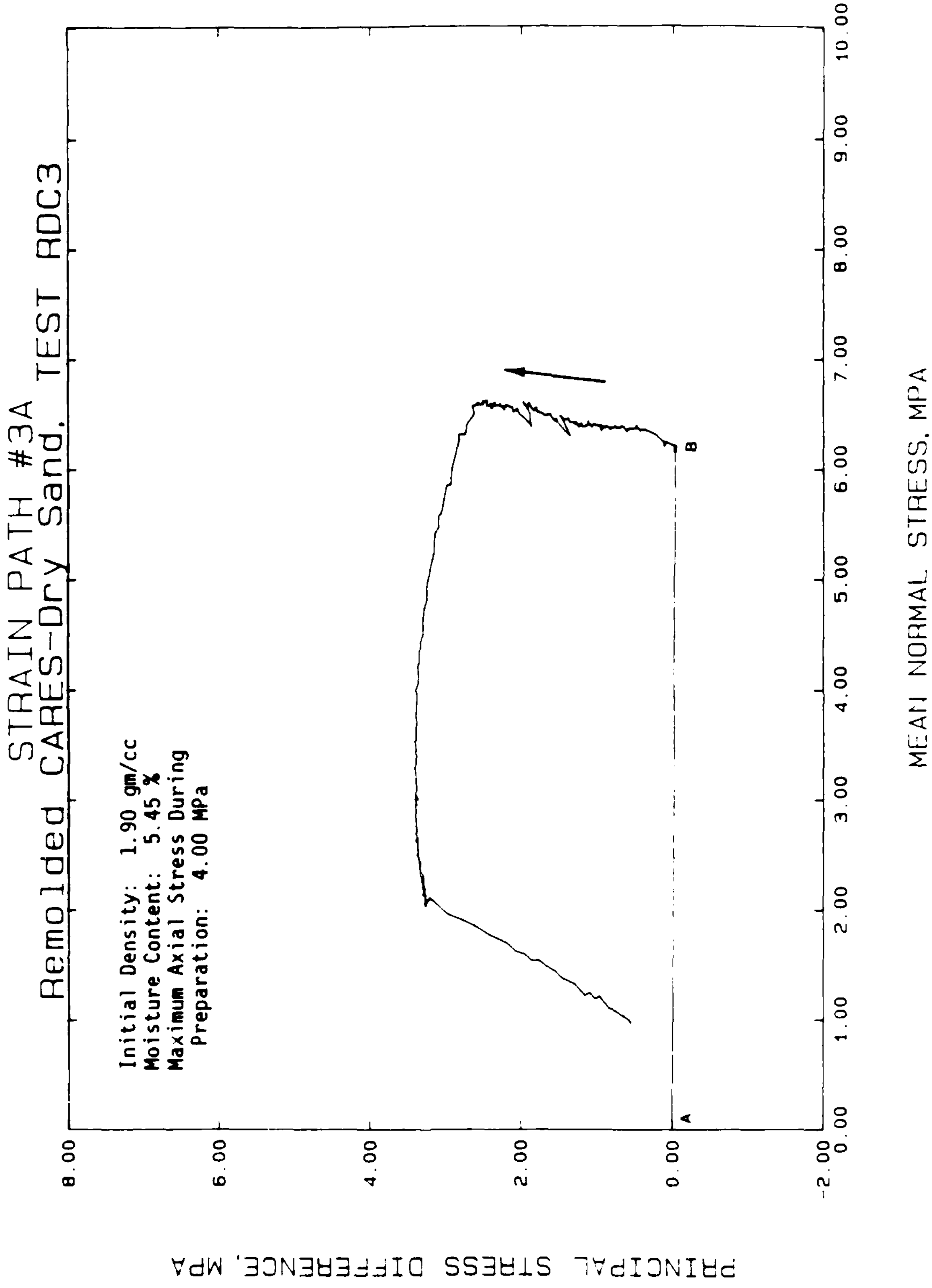

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.90 gm/cc
Moisture Content: 5.45 %
Maximum Axial Stress During
Preparation: 4.00 MPa
A
B
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
-2.00
0.00
2.00
4.00
6.00
8.00
MEAN NORMAL STRESS, MPA
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 179

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC3

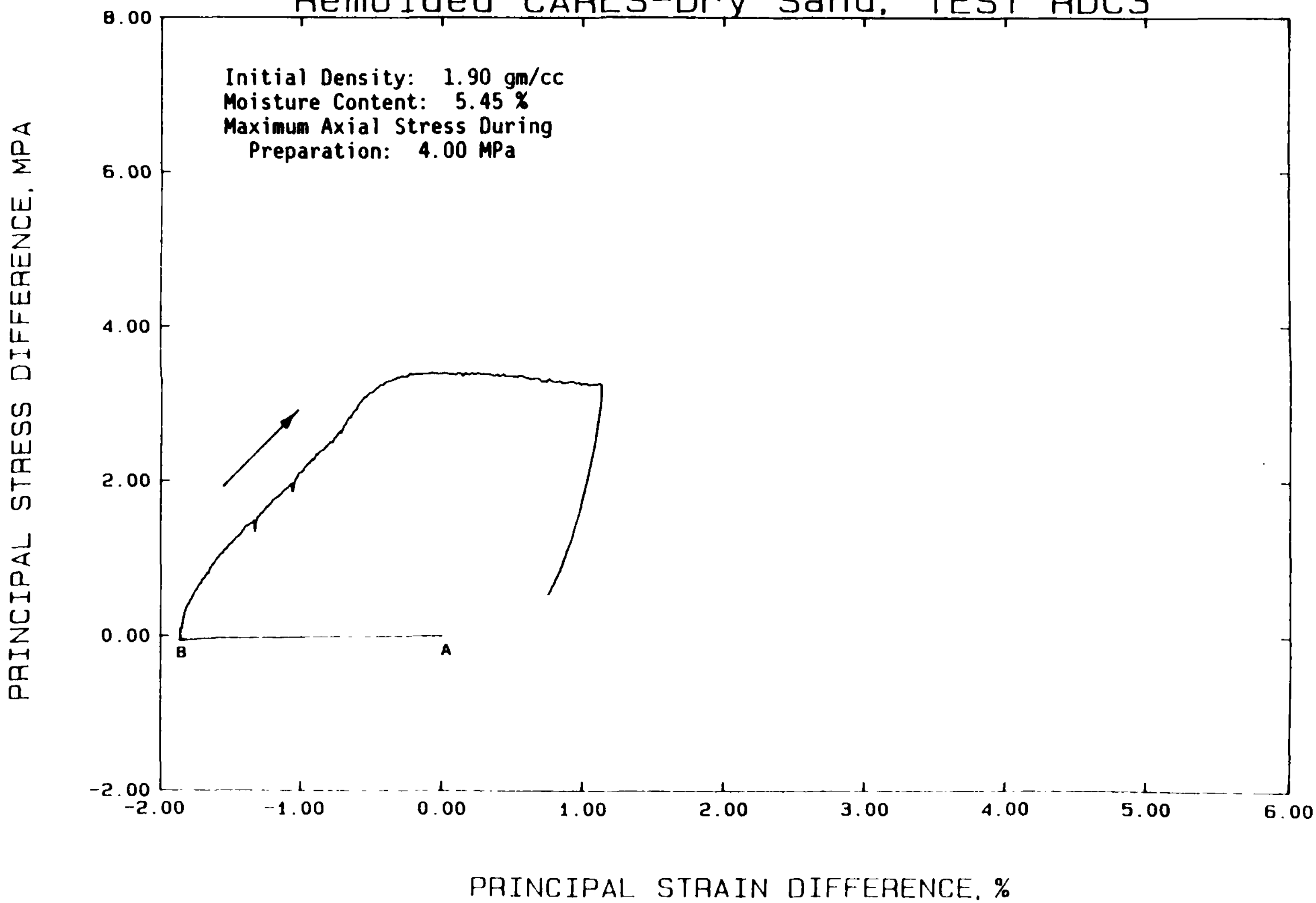


Plate 180

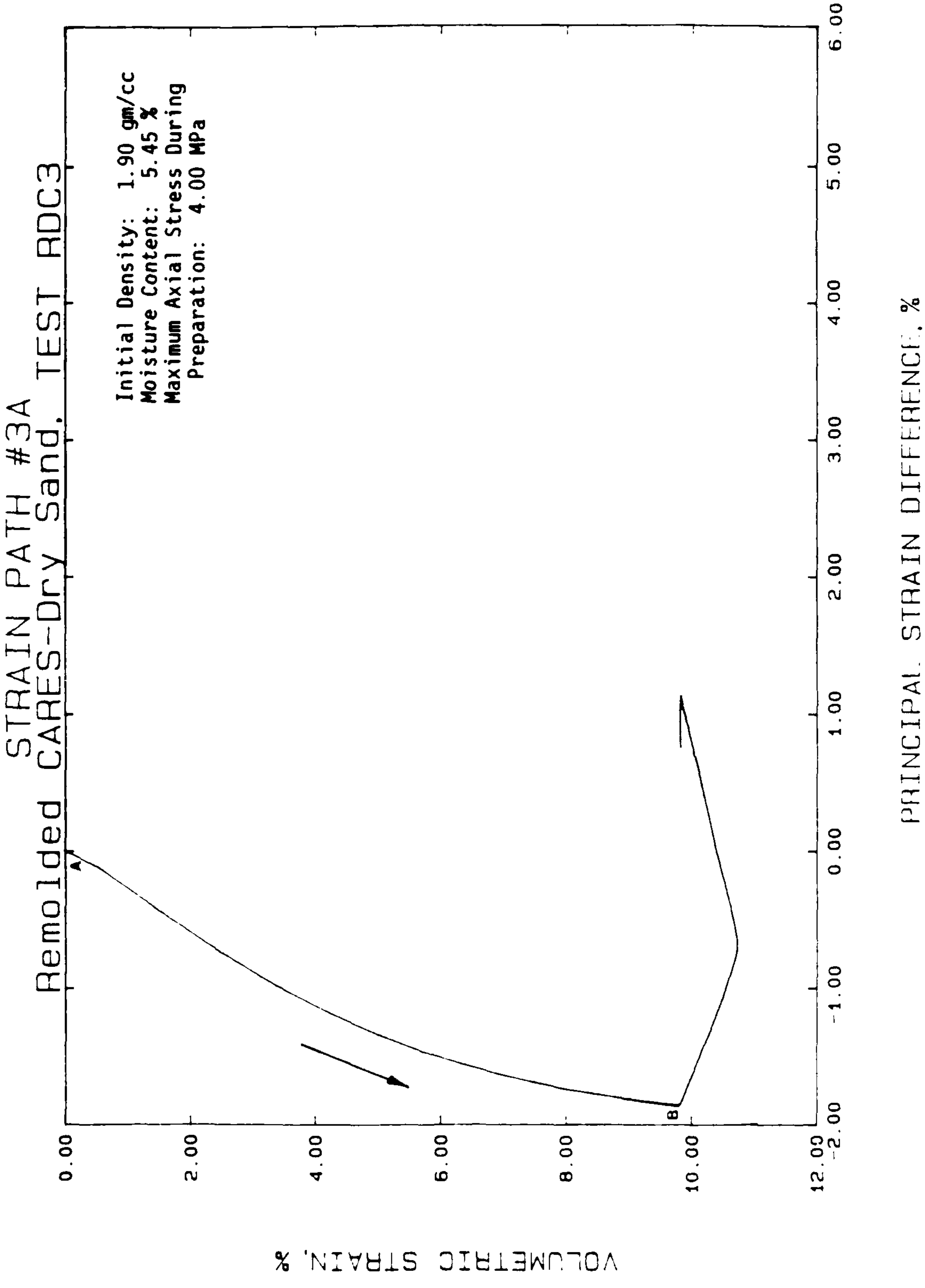

STRAIN PATH #3A
Remolded CARES-Dry Sand. TEST RDC3
Initial Density: 1.90 gm/cc
Moisture Content: 5.45 %
Maximum Axial Stress During
Preparation: 4.00 MPa
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %

Plate 181

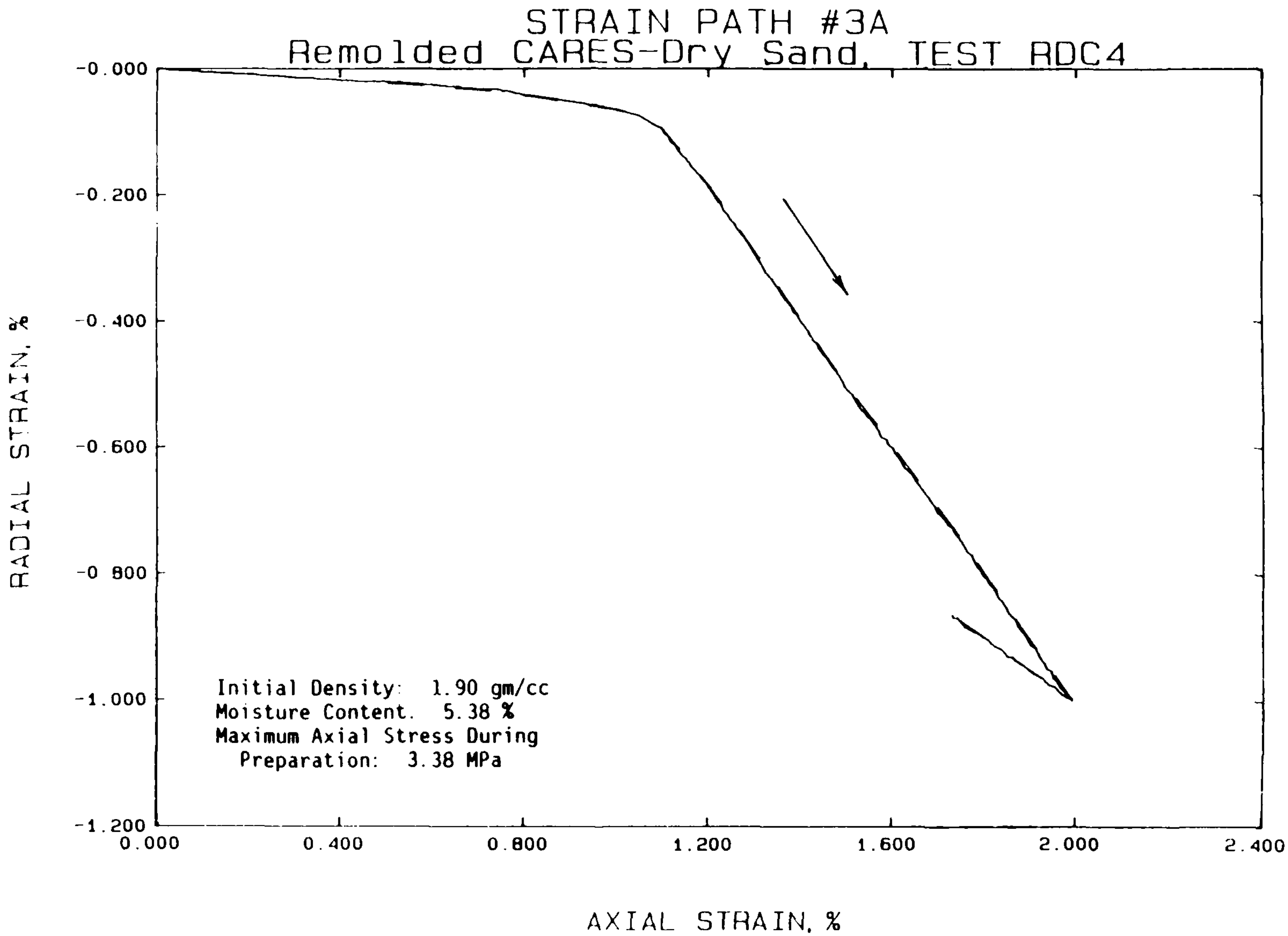
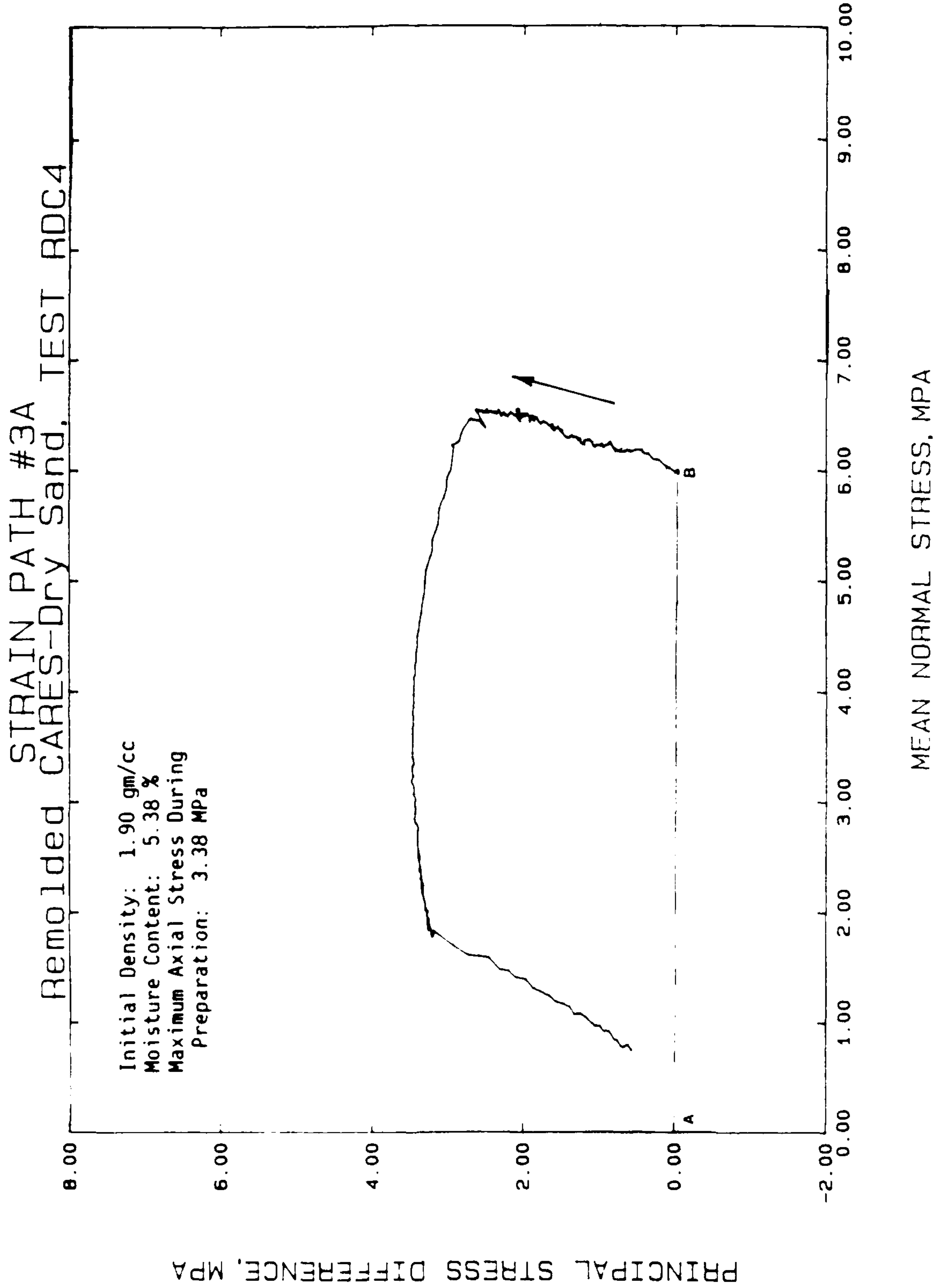
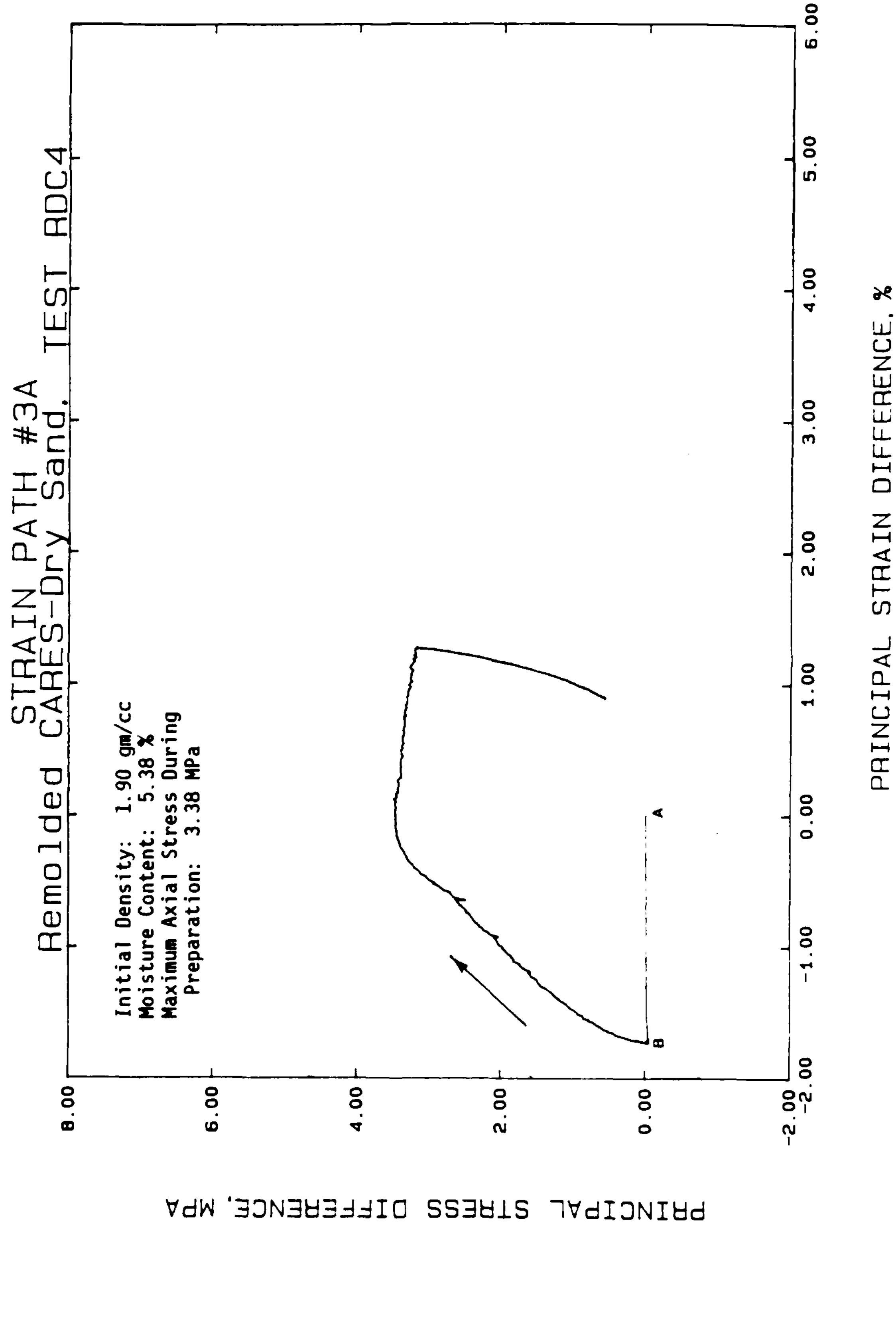

STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC4
RADIAL STRAIN, %
AXIAL STRAIN, %
-0.000
-0.200
-0.400
-0.600
-0 800
-1.000
-1.200
0.000
0.400
0.800
1.200
1.600
2.000
2.400
Initial Density: 1.90 gm/cc
Moisture Content. 5.38 %
Maximum Axial Stress During
Preparation: 3.38 MPa

Plate 182


STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC4
Initial Density: 1.90 gm/cc
Moisture Content: 5.38 %
Maximum Axial Stress During
Preparation: 3.38 MPa
A
B
-2.00
0.00
2.00
4.00
6.00
8.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA



STRAIN PATH #3A
Remolded CARES-Dry Sand, TEST RDC4
Initial Density: 1.90 gm/cc
Moisture Content: 5.38 %
Maximum Axial Stress During
Preparation: 3.38 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
0.00
2.00
4.00
6.00
8.00
-1.00
1.00
3.00
5.00

Plate 184

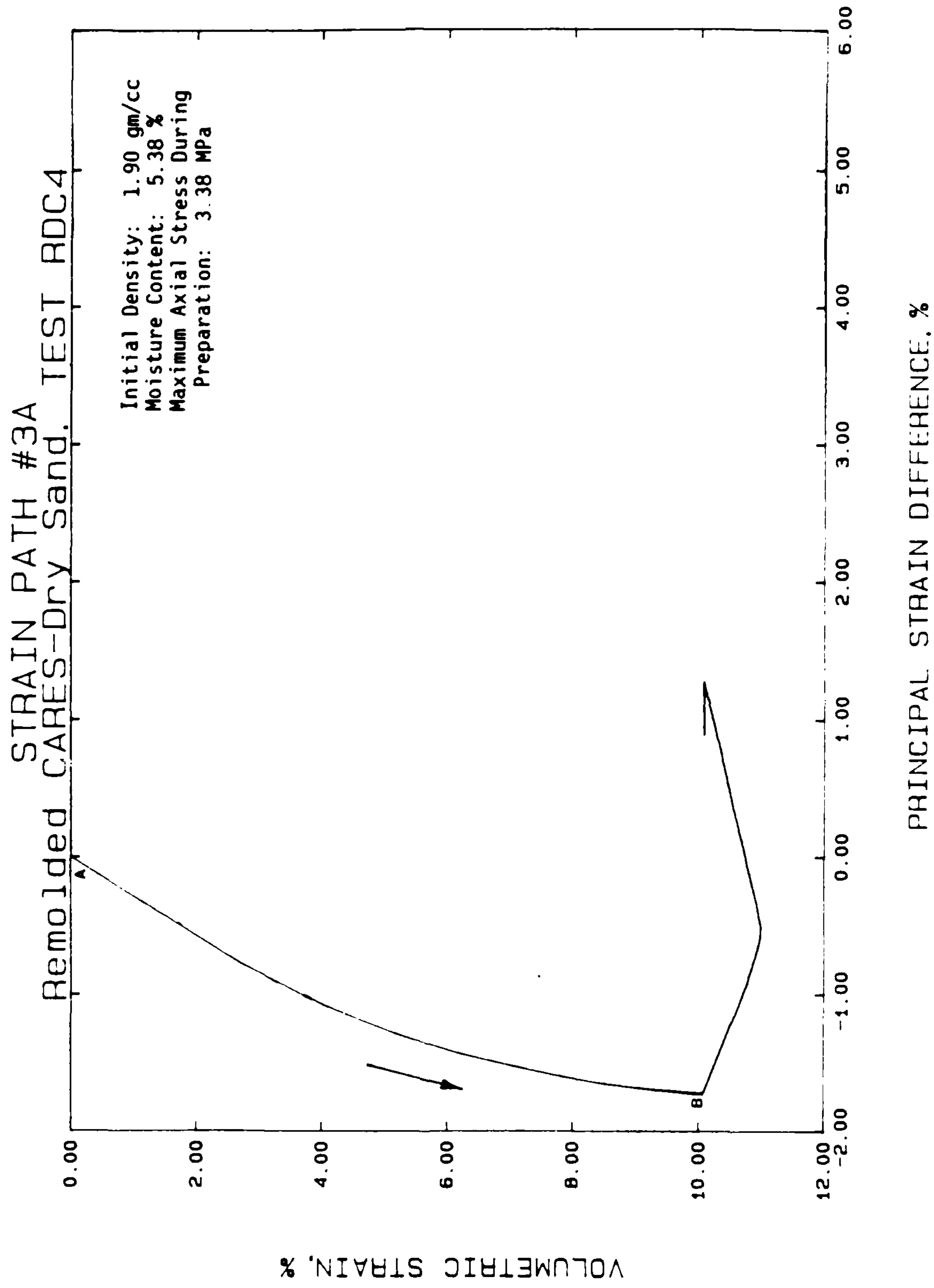

STRAIN PATH #3A
Remolded CARES-Dry Sand. TEST RDC4
Initial Density: 1.90 gm/cc
Moisture Content: 5.38 %
Maximum Axial Stress During
Preparation: 3.38 MPa
A
B
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
VOLUMETRIC STRAIN, %

Plate 185

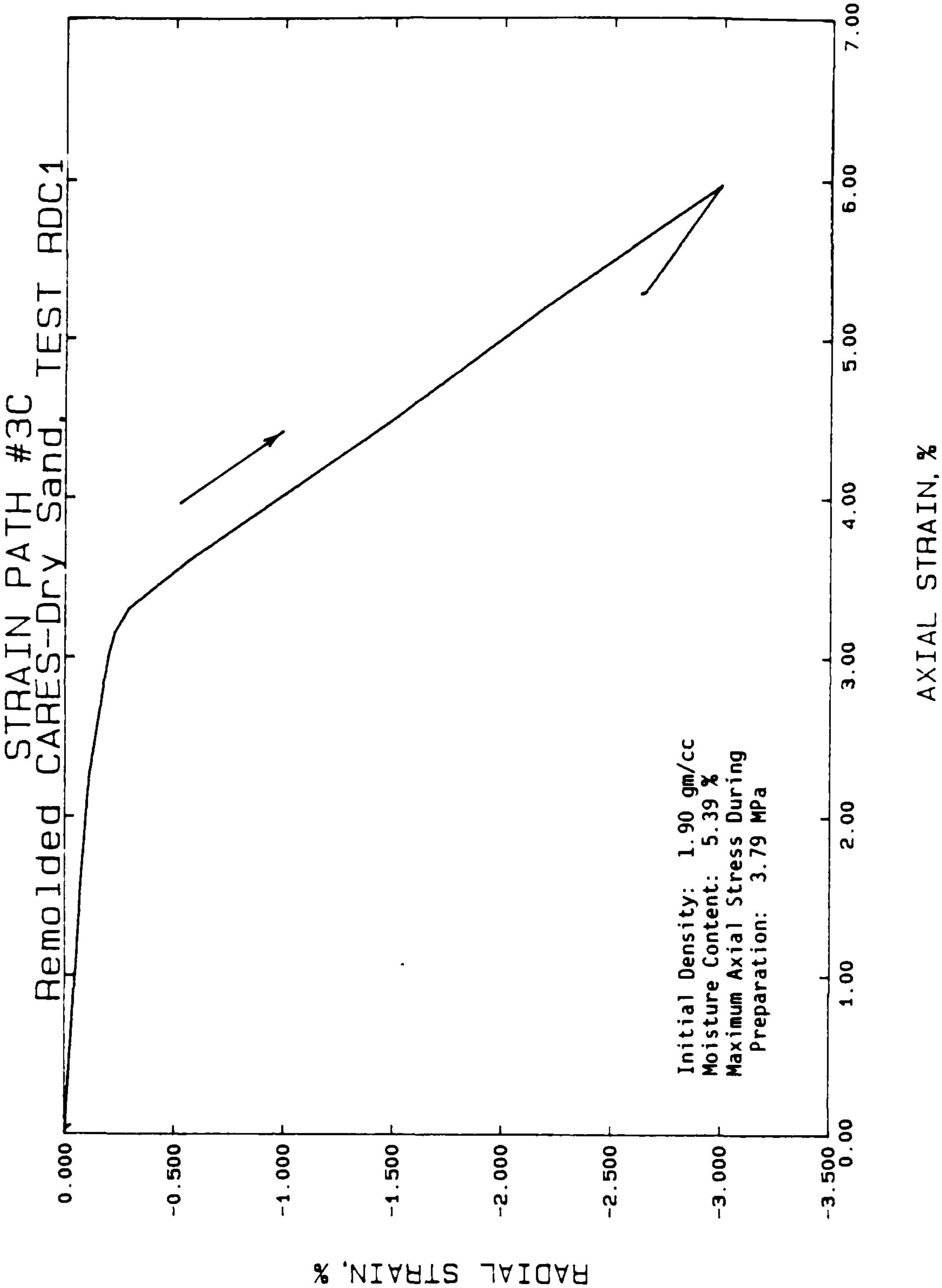

STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC1
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
-3.500
Initial Density: 1.90 gm/cc
Moisture Content: 5.39 %
Maximum Axial Stress During
Preparation: 3.79 MPa

Plate 186

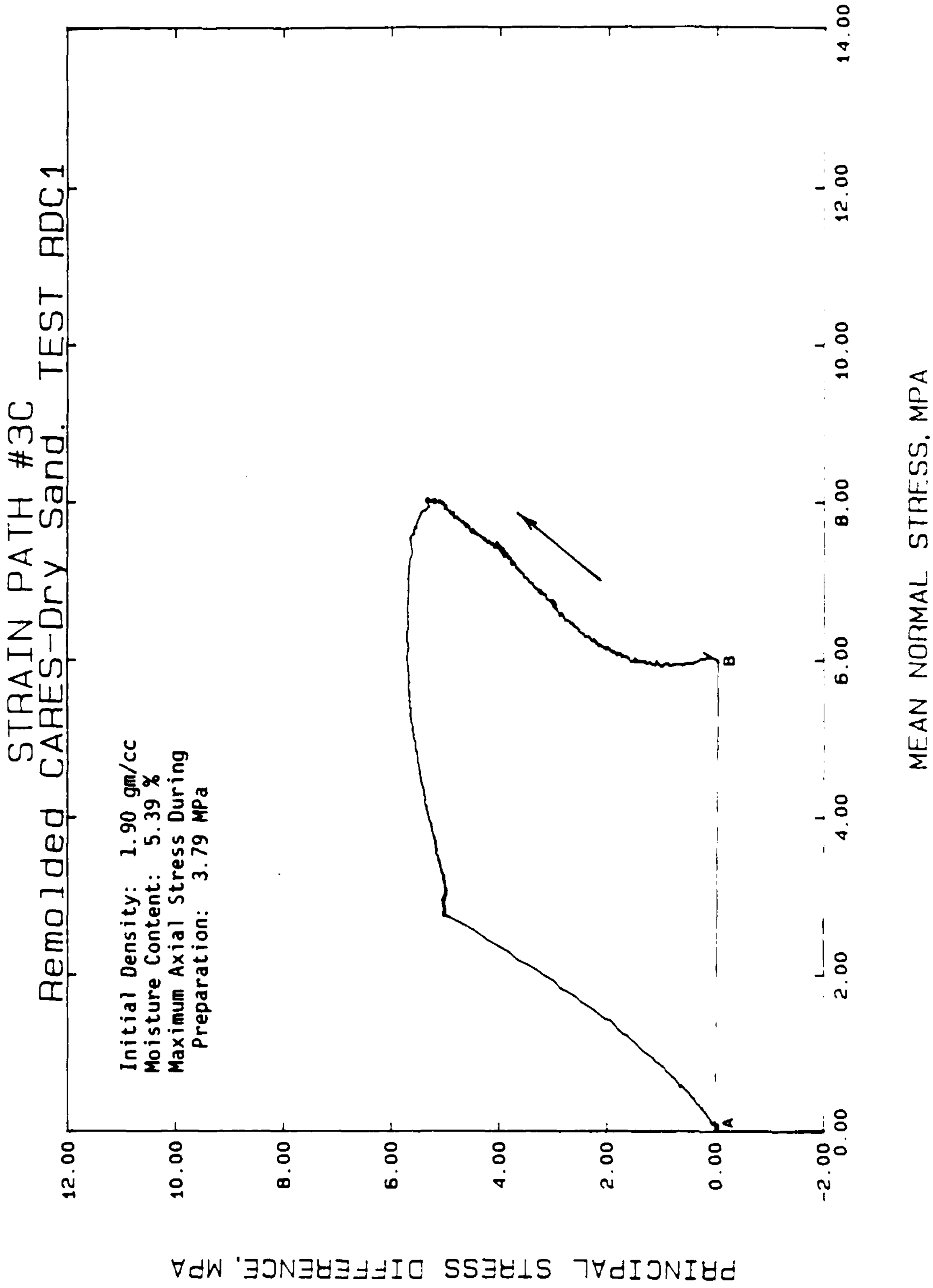

STRAIN PATH #3C
Remolded CARES-Dry Sand. TEST RDC1
Initial Density: 1.90 gm/cc
Moisture Content: 5.39 %
Maximum Axial Stress During
Preparation: 3.79 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
MEAN NORMAL STRESS, MPA
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 187

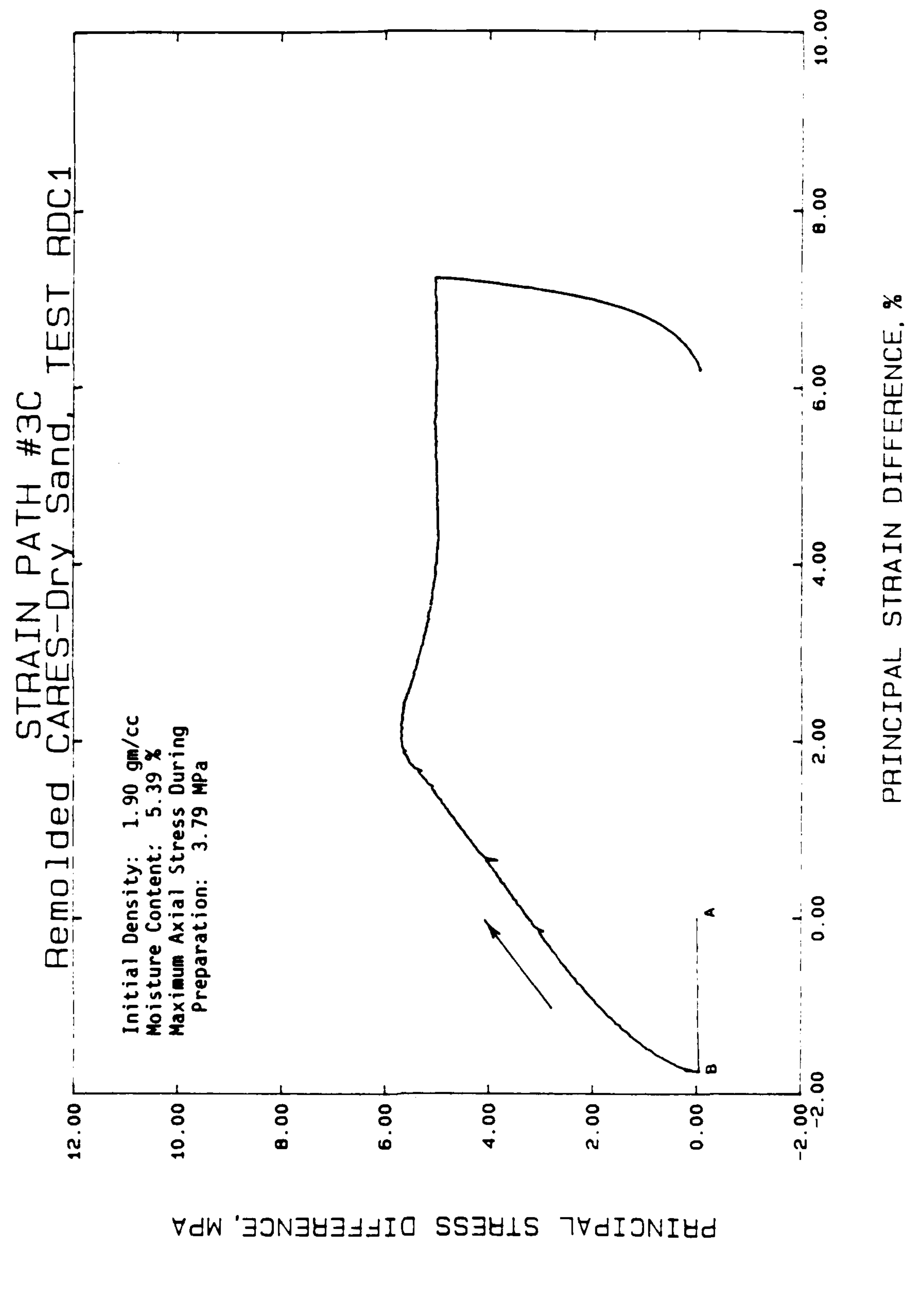

STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.90 gm/cc
Moisture Content: 5.39 %
Maximum Axial Stress During
Preparation: 3.79 MPa
A
B
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00

Plate 188

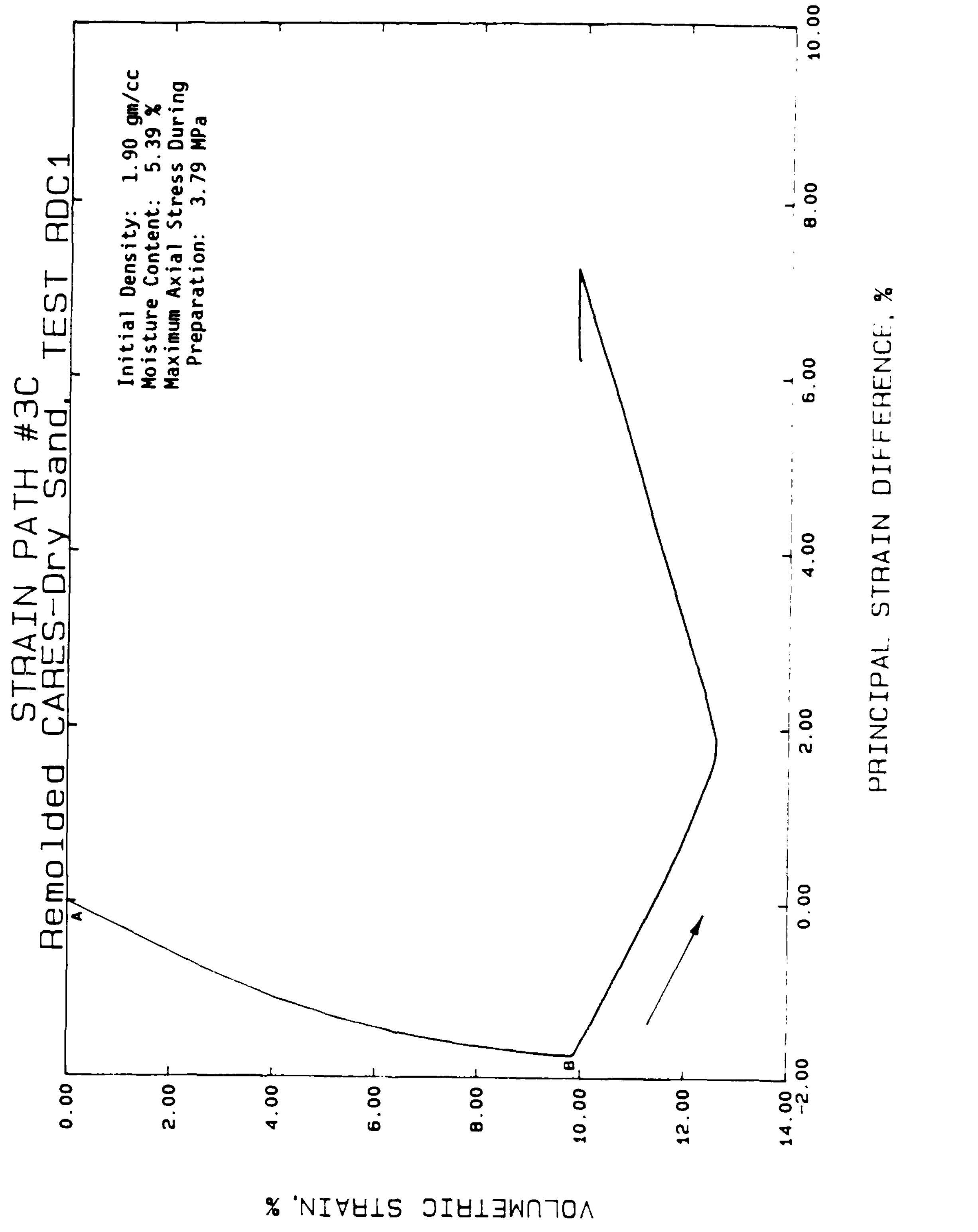

STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC1
Initial Density: 1.90 gm/cc
Moisture Content: 5.39 %
Maximum Axial Stress During
Preparation: 3.79 MPa
A
B
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
0.00
2.00
4.00
6.00
8.00
10.00

Plate 189

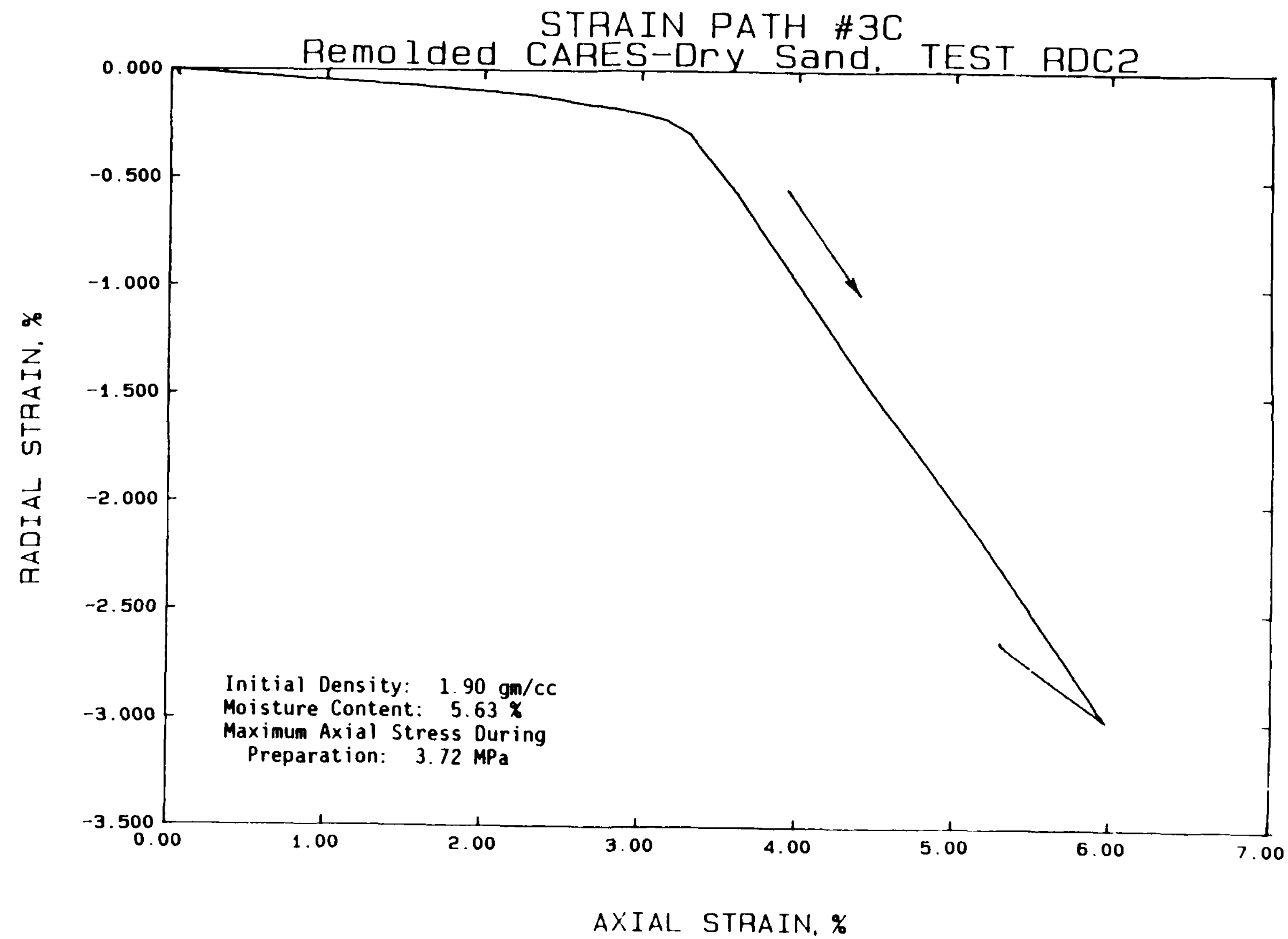

STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC2
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
-3.500
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
AXIAL STRAIN, %
Initial Density: 1.90 gm/cc
Moisture Content: 5.63 %
Maximum Axial Stress During
Preparation: 3.72 MPa

Plate 190

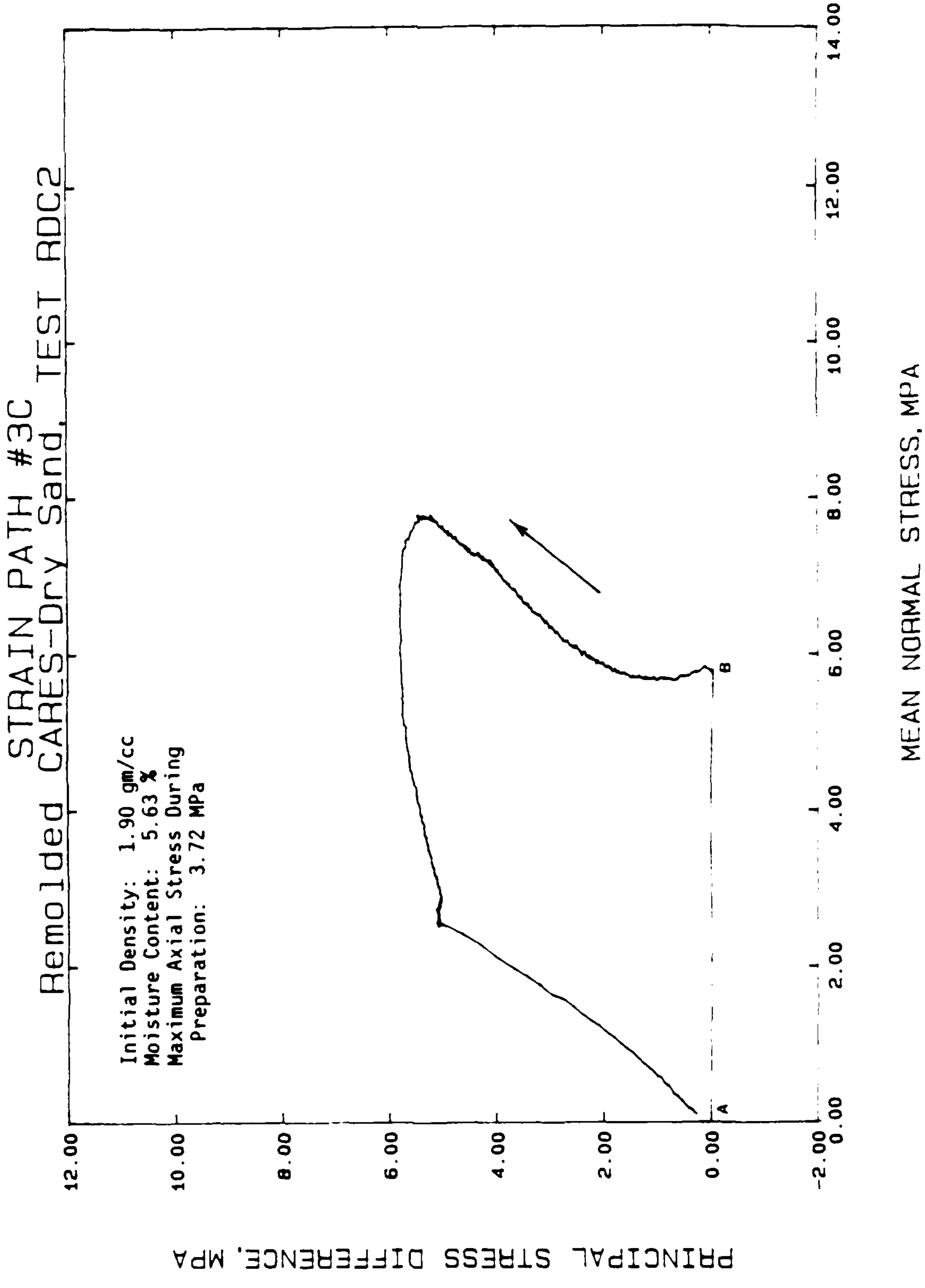

STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.90 gm/cc
Moisture Content: 5.63 %
Maximum Axial Stress During
Preparation: 3.72 MPa
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
14.00
A
B

Plate 191

STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC2

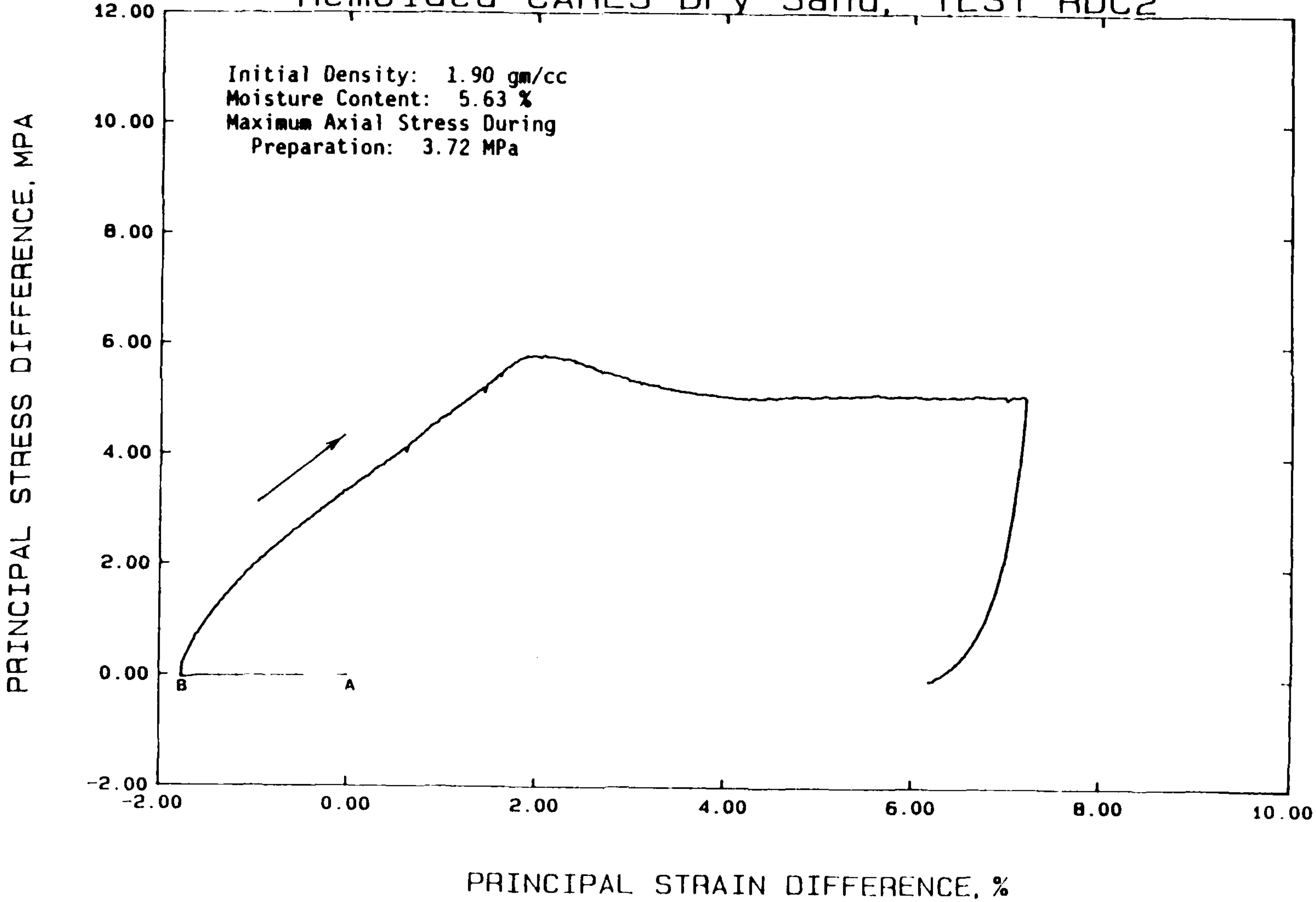
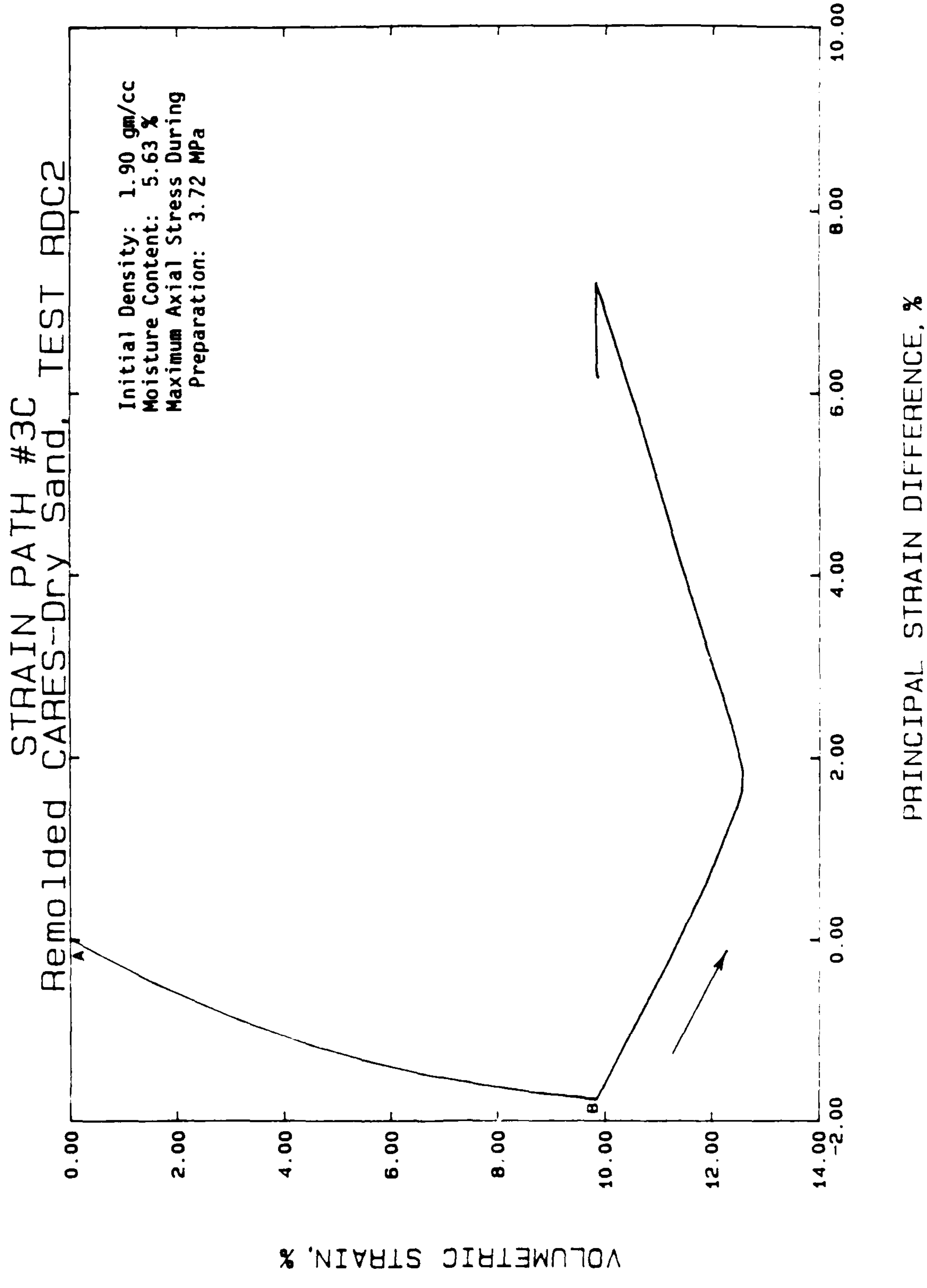


Plate 192



STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC2
Initial Density: 1.90 gm/cc
Moisture Content: 5.63 %
Maximum Axial Stress During
Preparation: 3.72 MPa
A
B
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
0.00
2.00
4.00
6.00
8.00
10.00

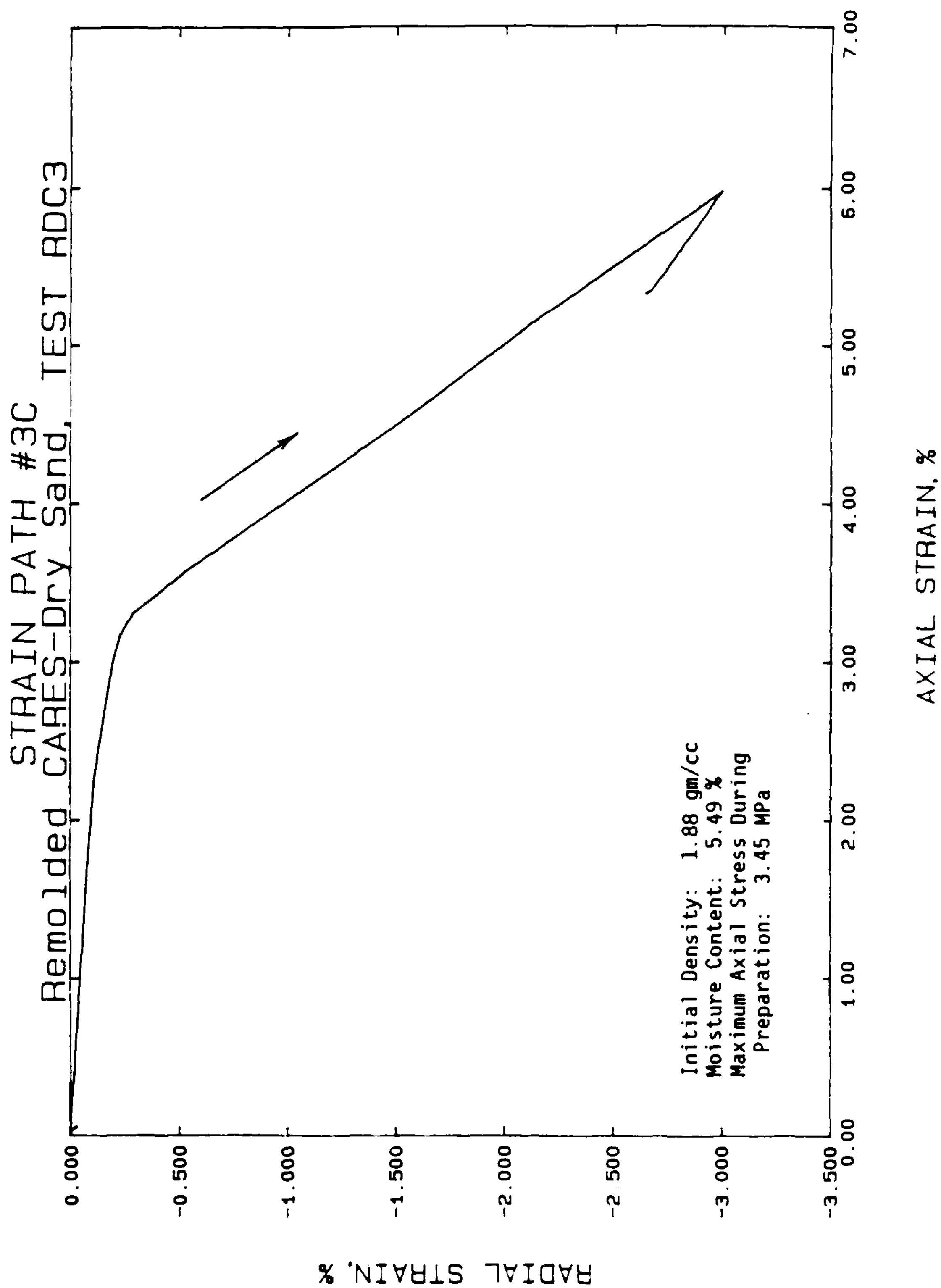

STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.88 gm/cc
Moisture Content: 5.49 %
Maximum Axial Stress During
Preparation: 3.45 MPa
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
-3.500

Plate 194

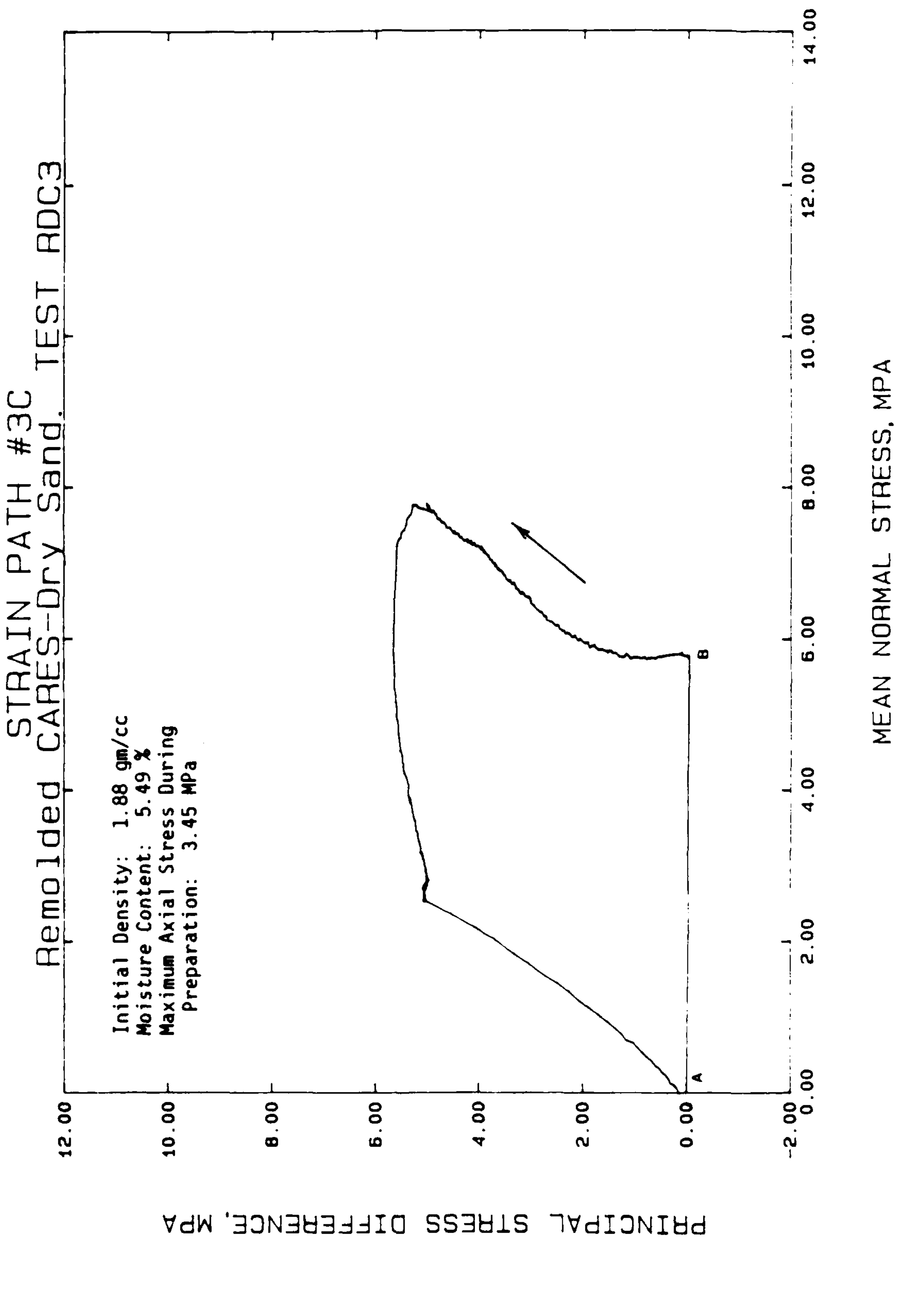

STRAIN PATH #3C
Remolded CARES-Dry Sand. TEST RDC3
Initial Density: 1.88 gm/cc
Moisture Content: 5.49 %
Maximum Axial Stress During
Preparation: 3.45 MPa
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 195

STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC3

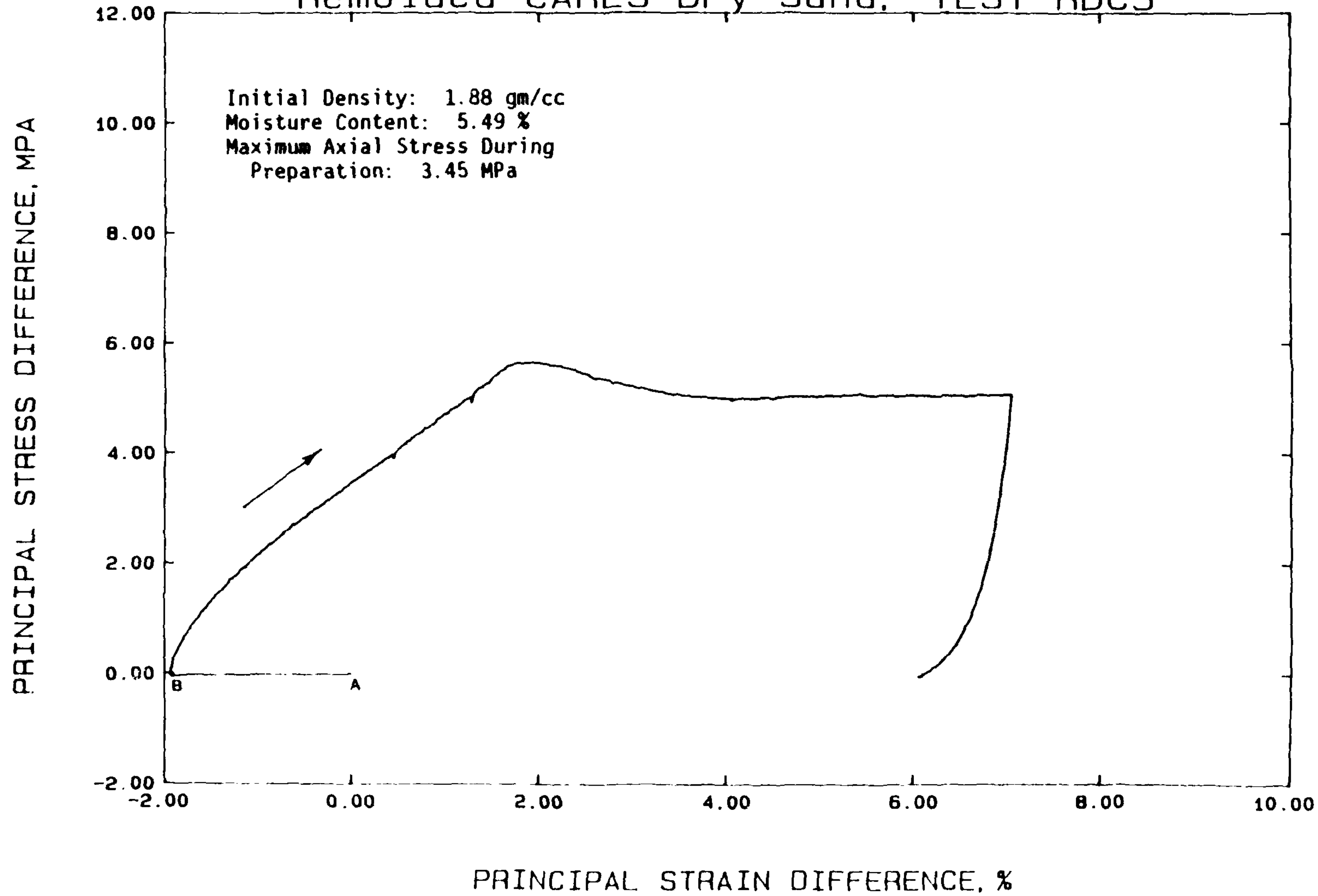


Plate 196

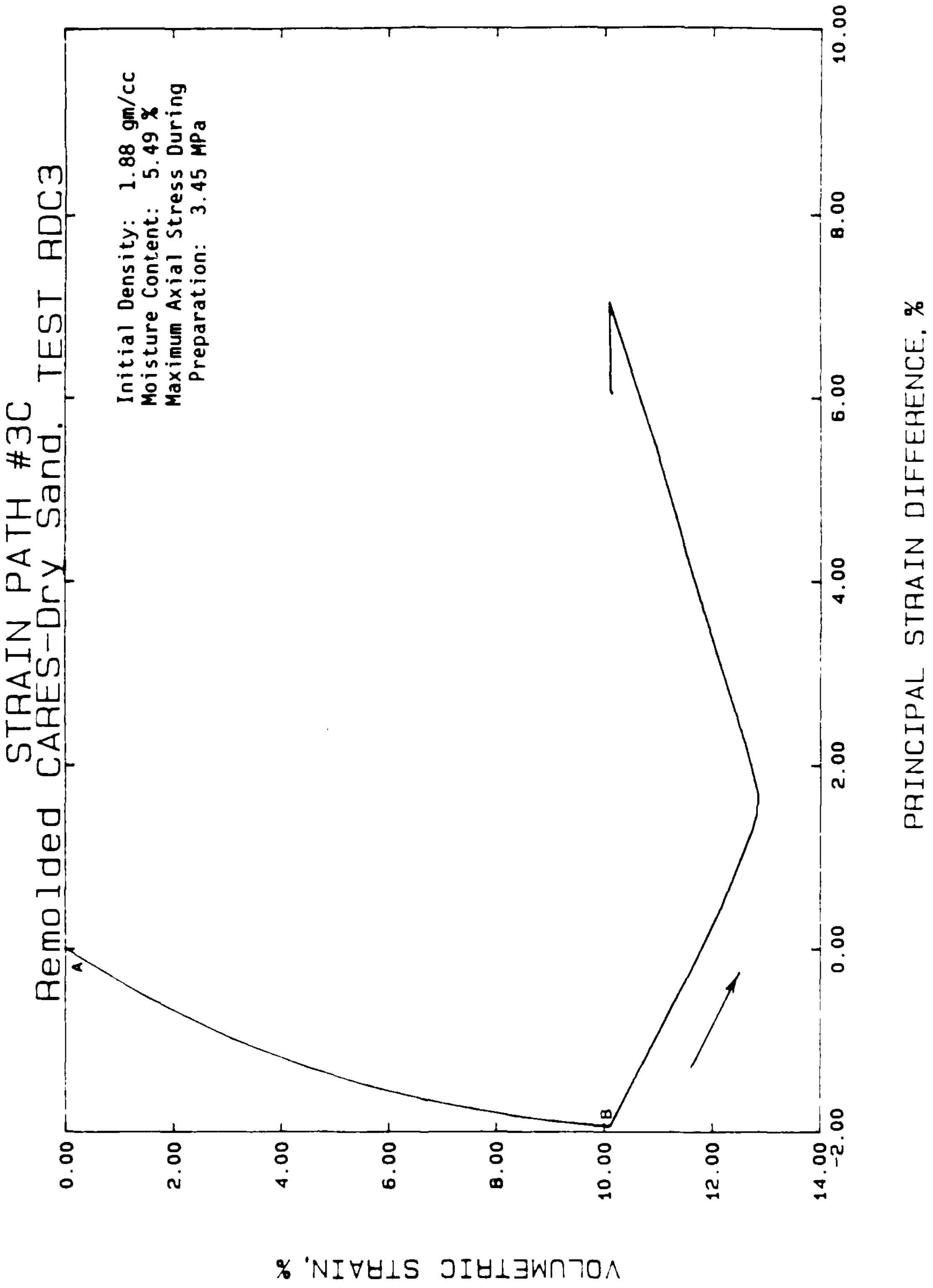
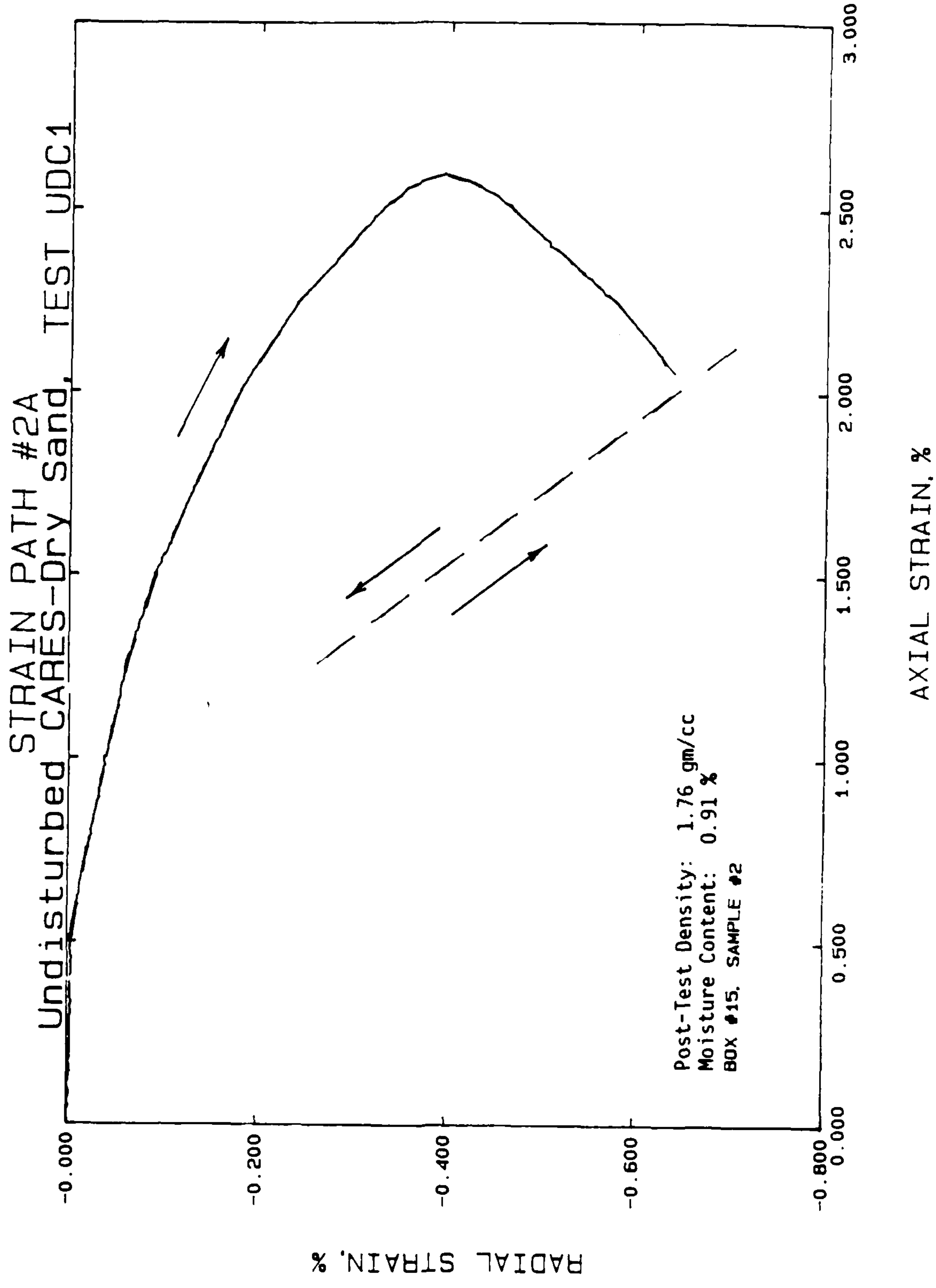

STRAIN PATH #3C
Remolded CARES-Dry Sand, TEST RDC3
Initial Density: 1.88 gm/cc
Moisture Content: 5.49 %
Maximum Axial Stress During
Preparation: 3.45 MPa
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %

Plate 197



STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.76 gm/cc
Moisture Content: 0.91 %
BOX #15, SAMPLE #2
-0.000
-0.200
-0.400
-0.600
-0.800
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
AXIAL STRAIN, %

Plate 198

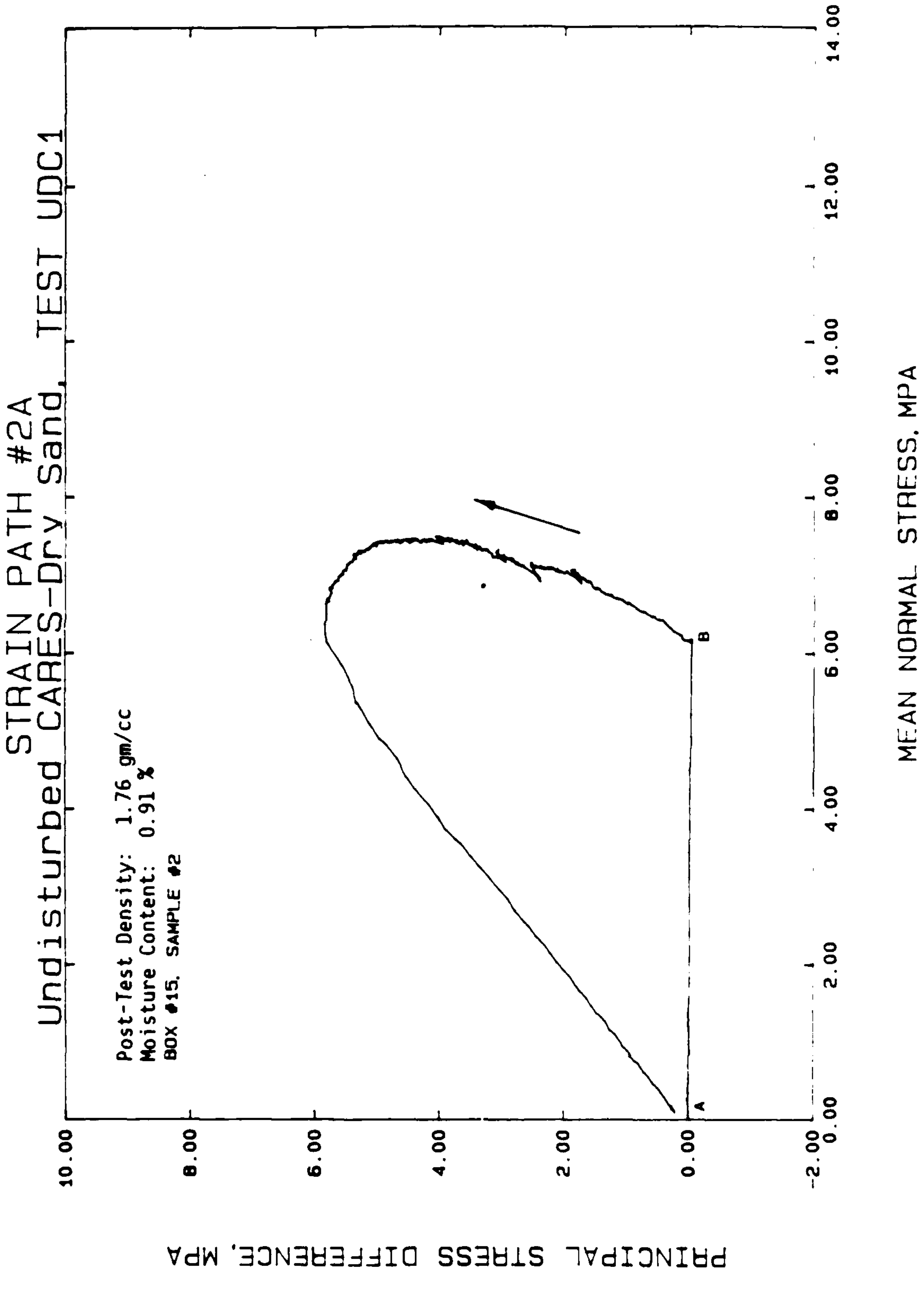

STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.76 gm/cc
Moisture Content: 0.91 %
BOX #15, SAMPLE #2
A
B
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA

Plate 199

STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC1

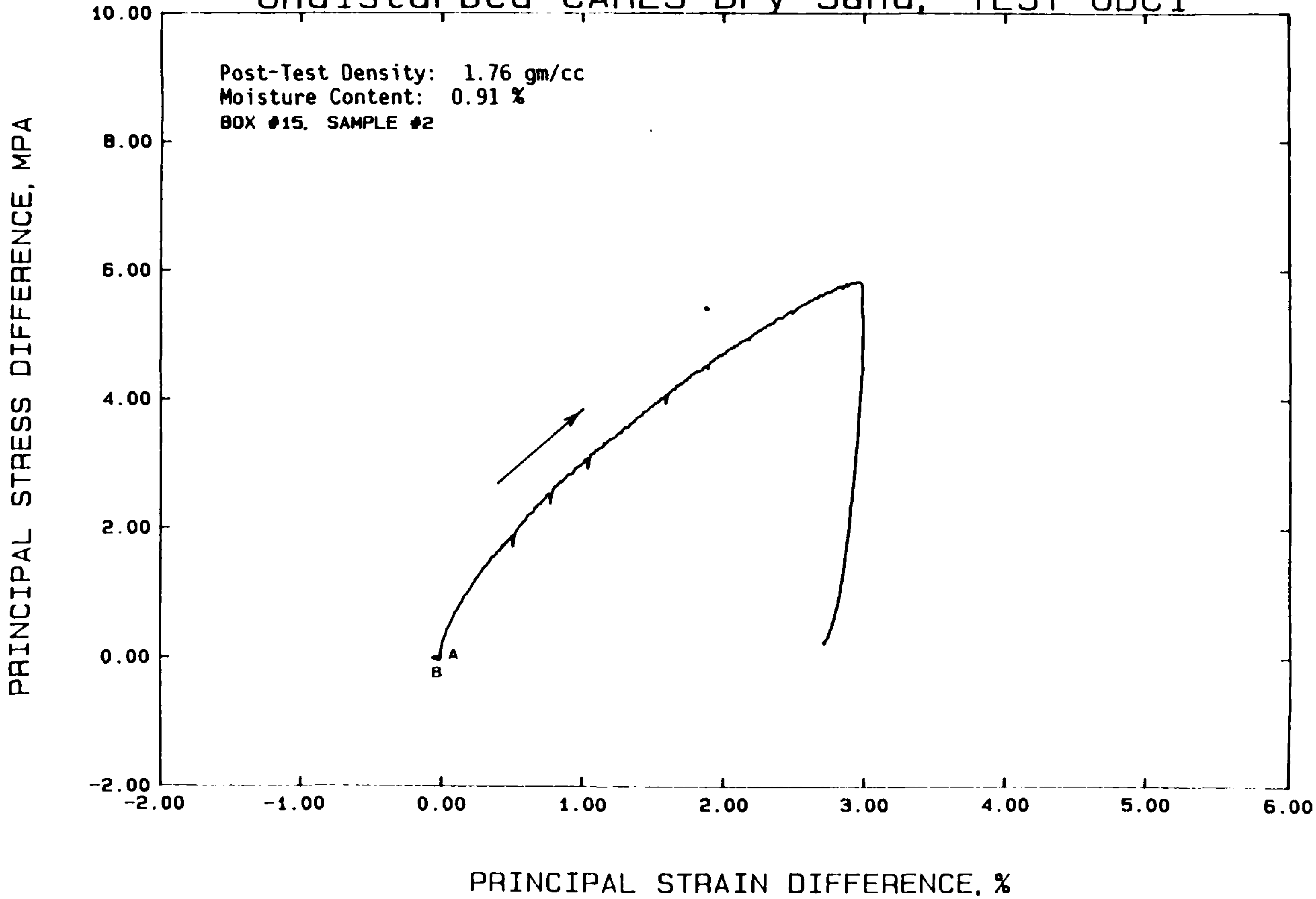
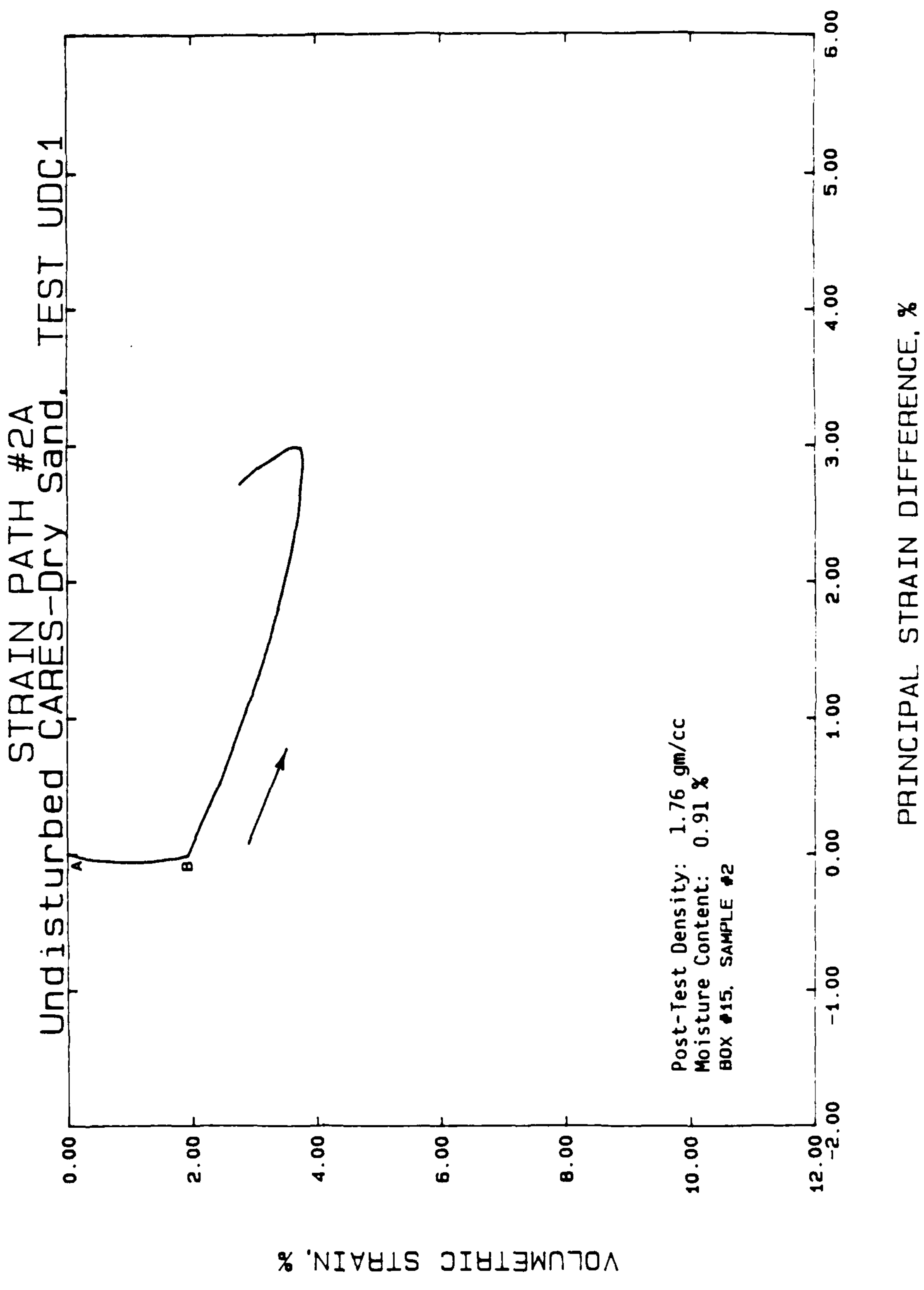


Plate 200


STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.76 gm/cc
Moisture Content: 0.91 %
BOX #15, SAMPLE #2
A
B
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
VOLUMETRIC STRAIN, %

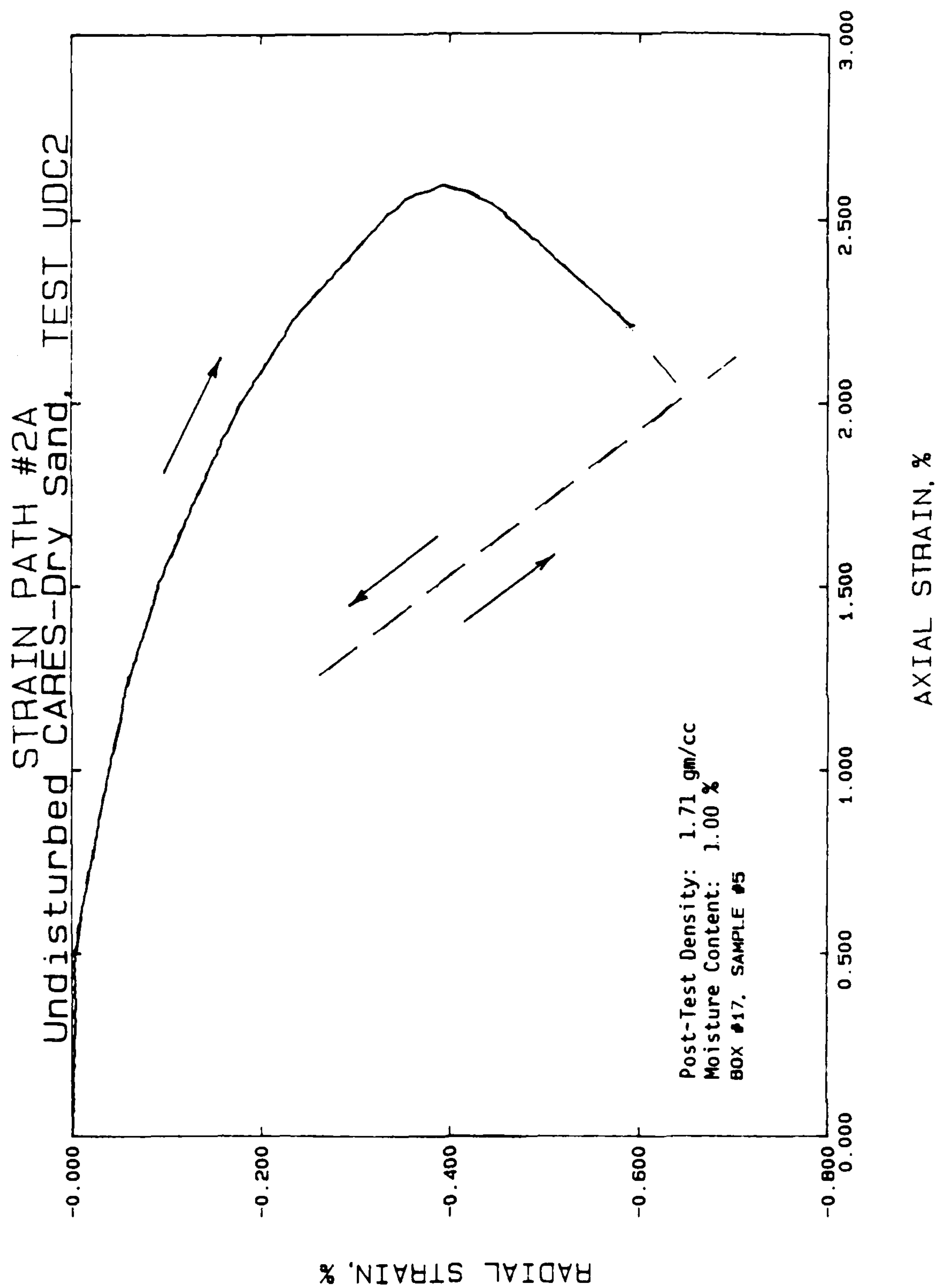
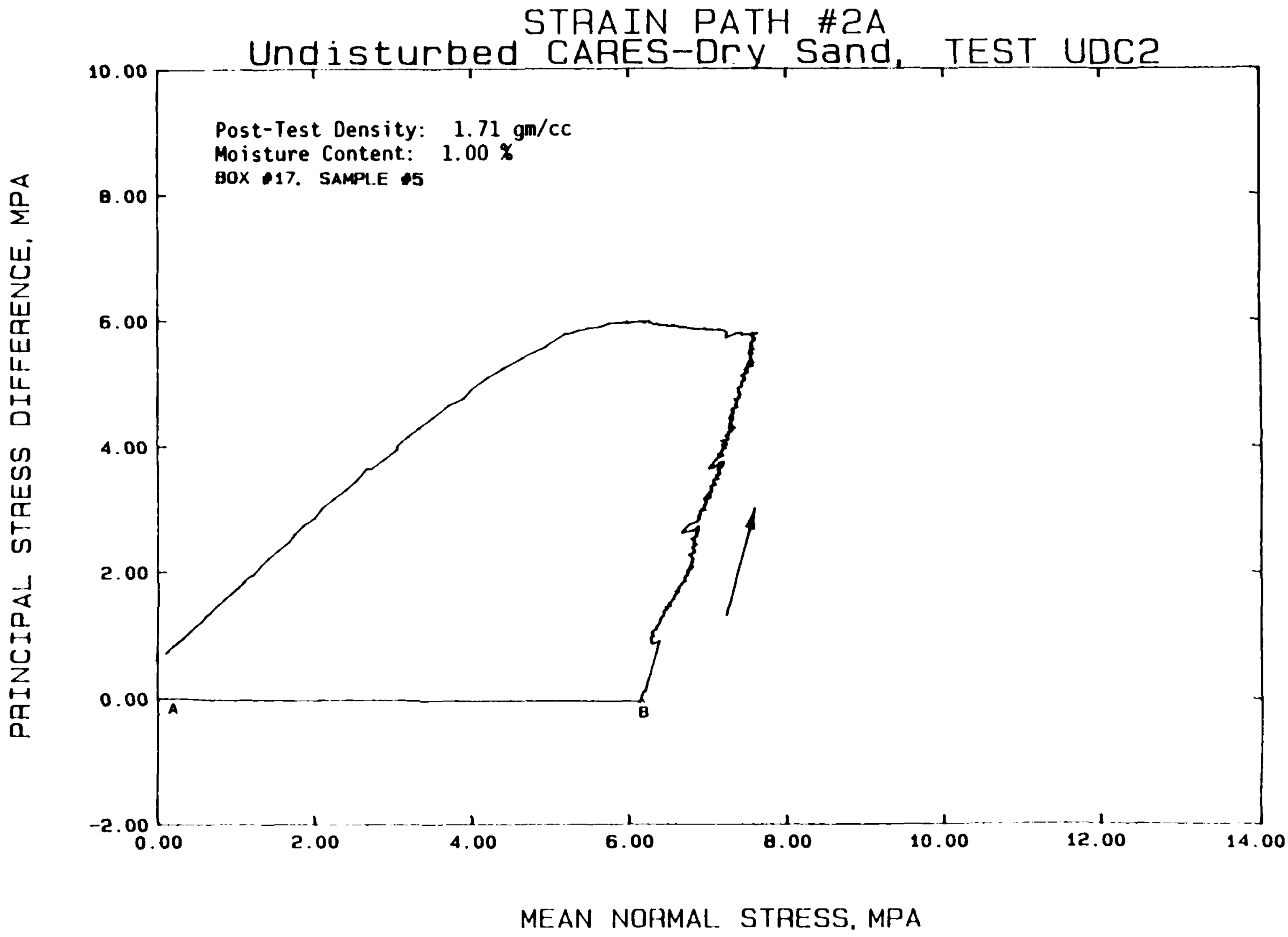
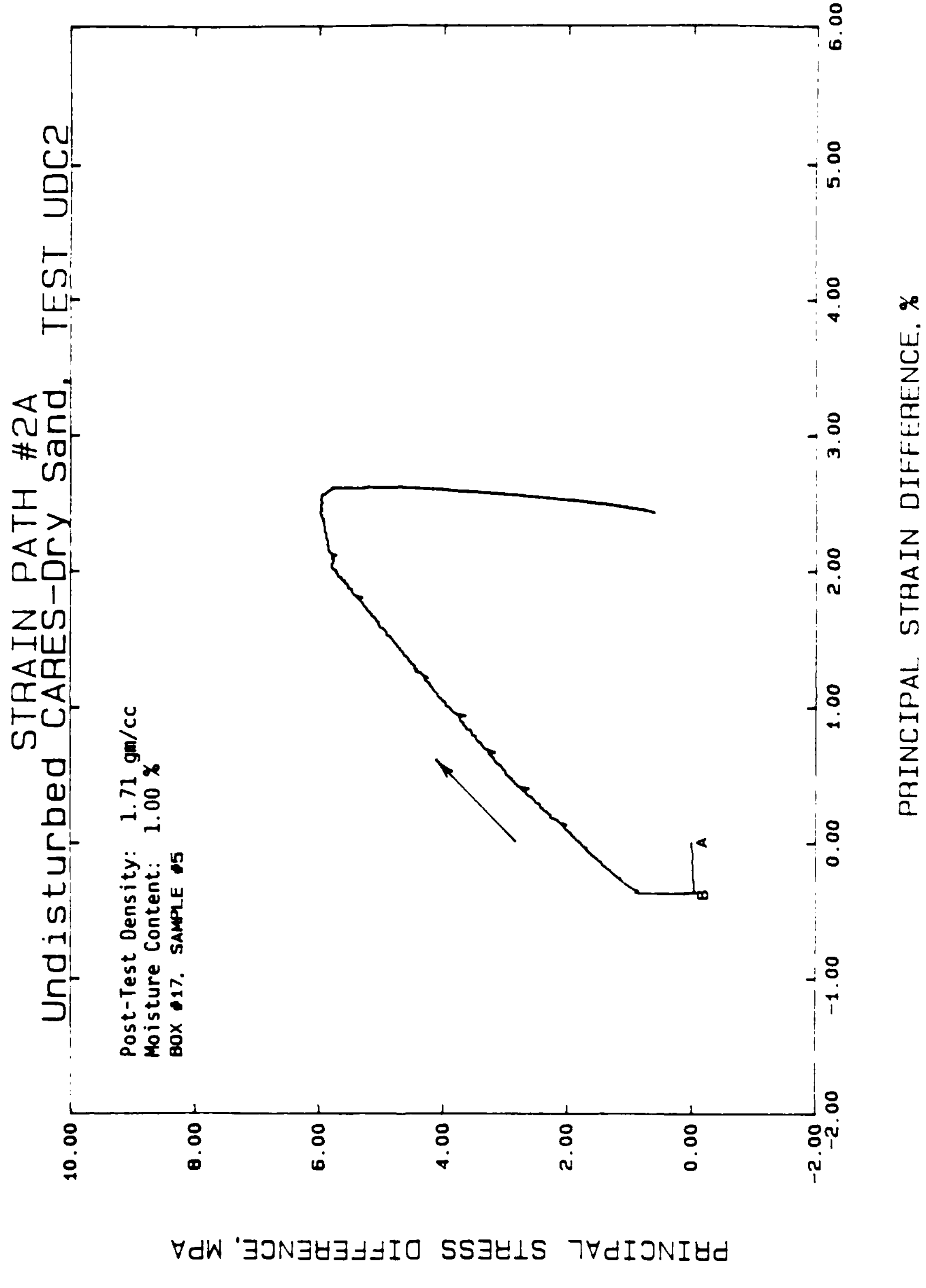
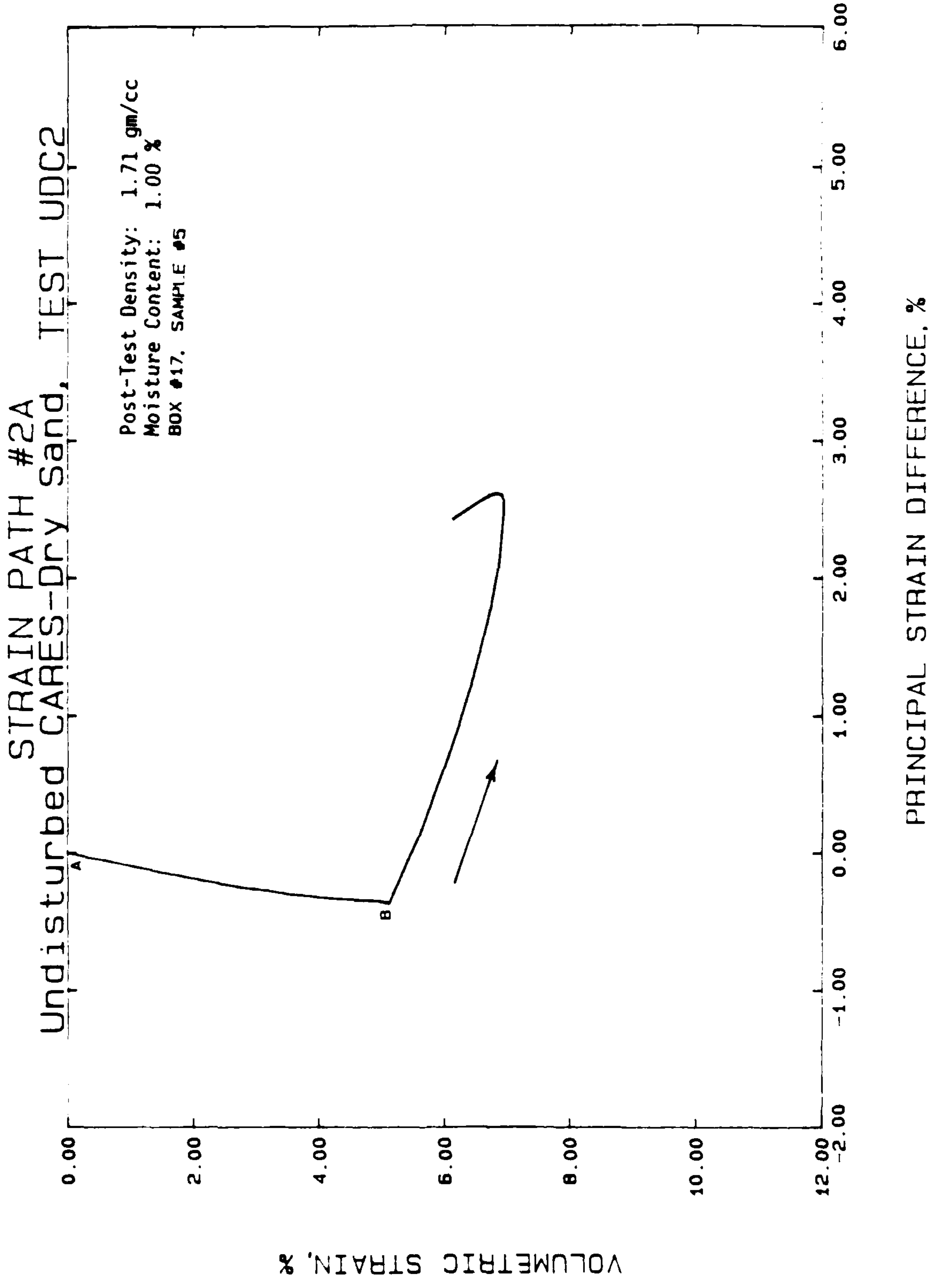

STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.71 gm/cc
Moisture Content: 1.00 %
BOX #17, SAMPLE #5
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

Plate 202

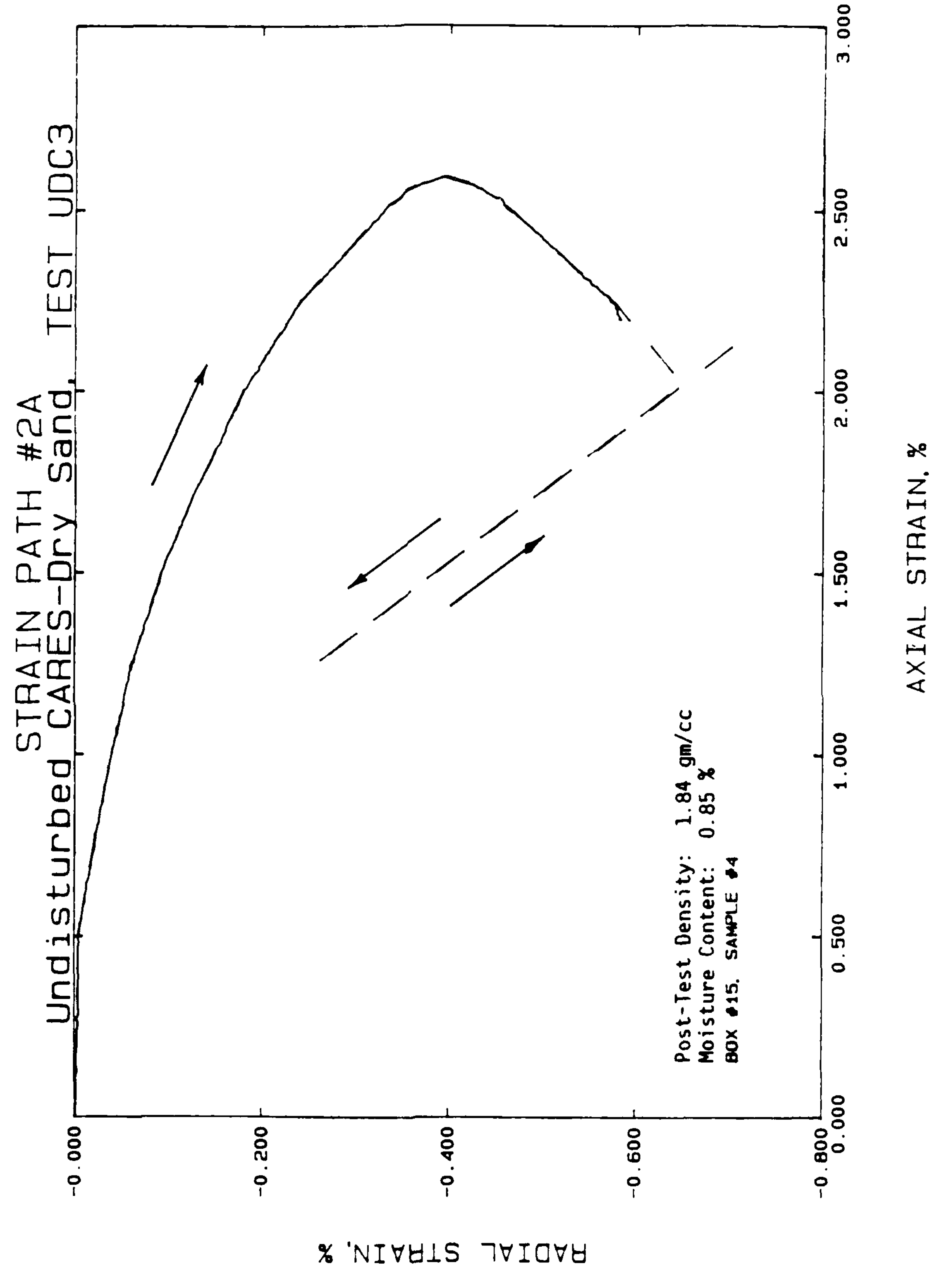

STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.71 gm/cc
Moisture Content: 1.00 %
BOX #17, SAMPLE #5
A
B
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA


STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.71 gm/cc
Moisture Content: 1.00 %
BOX #17, SAMPLE #5
A
B
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-1.00
1.00
3.00
5.00
6.00
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %



STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.71 gm/cc
Moisture Content: 1.00 %
BOX #17, SAMPLE #5
A
B
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
VOLUMETRIC STRAIN, %

Plate 205



STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.84 gm/cc
Moisture Content: 0.85 %
BOX #15, SAMPLE #4
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

Plate 206

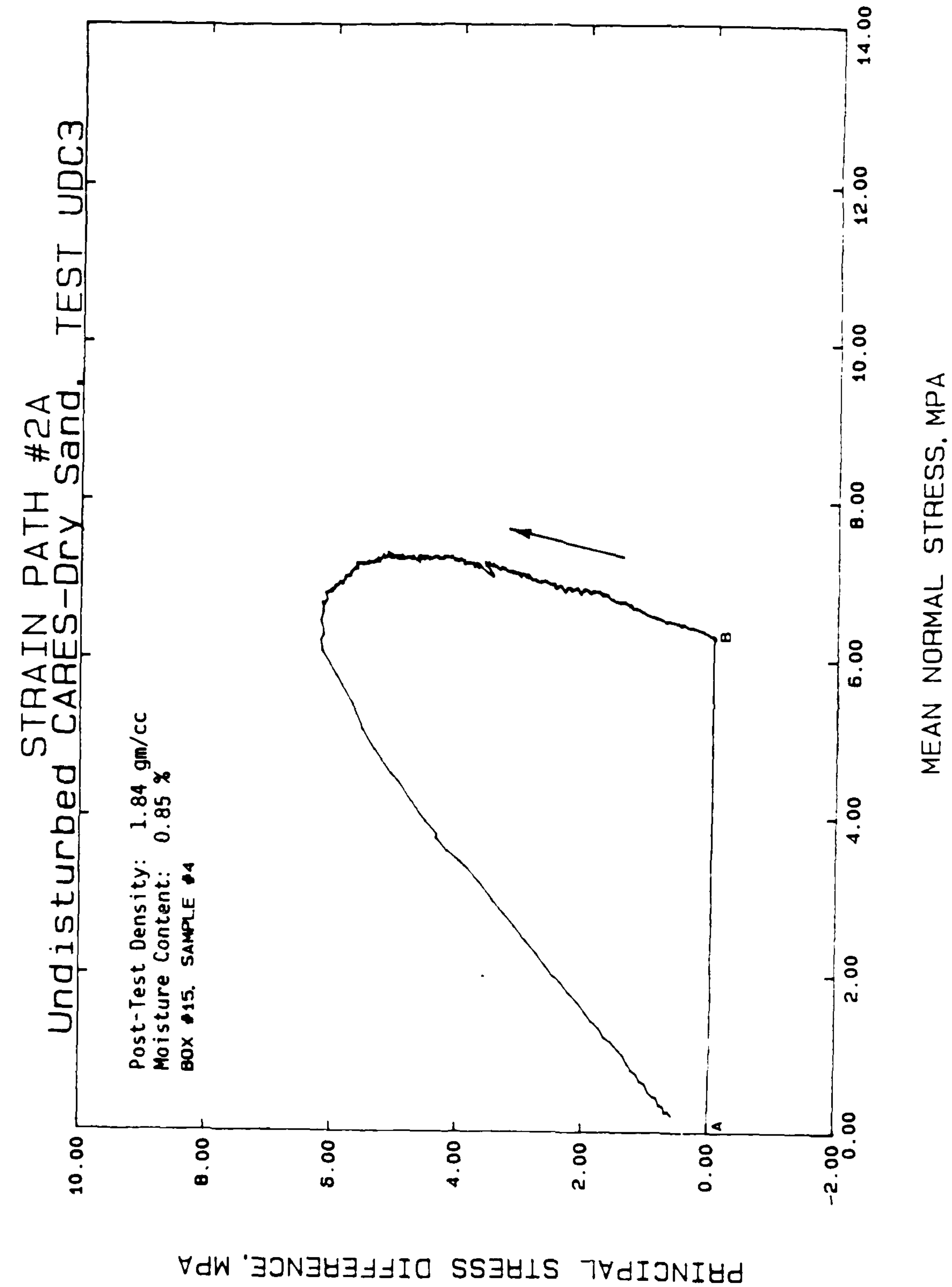
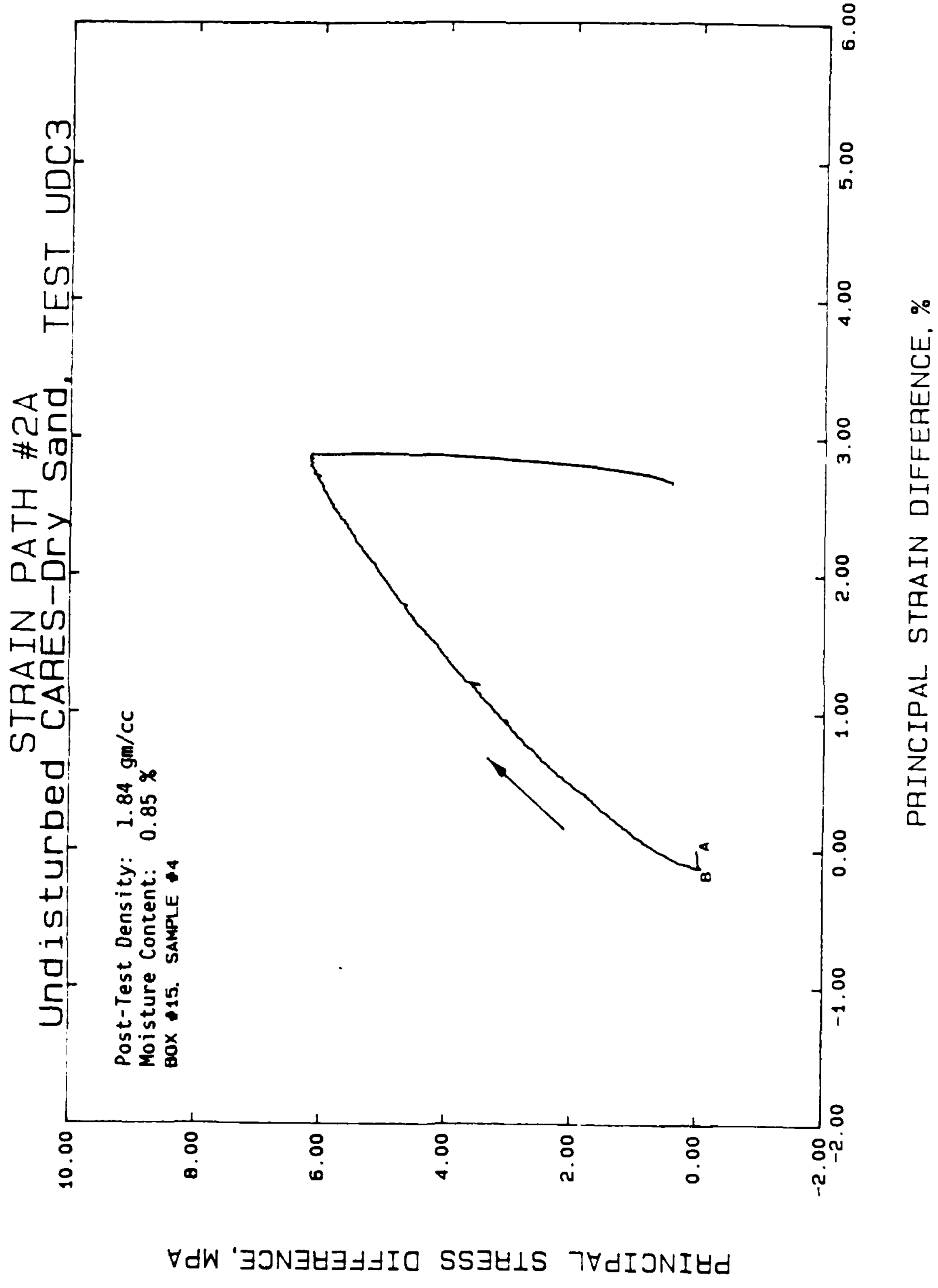
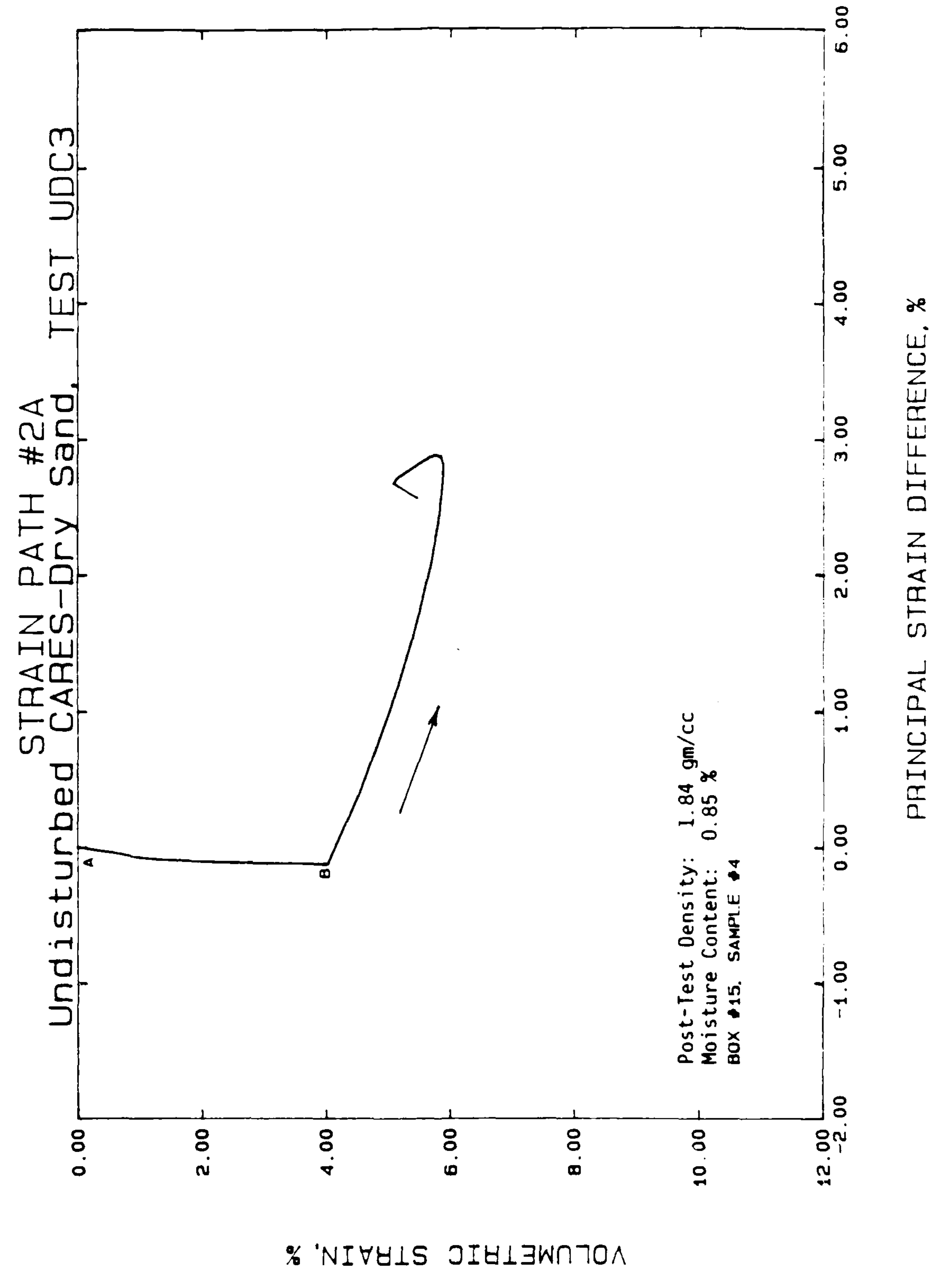

STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.84 gm/cc
Moisture Content: 0.85 %
BOX #15, SAMPLE #4
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
MEAN NORMAL STRESS, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 207



STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.84 gm/cc
Moisture Content: 0.85 %
BOX #15, SAMPLE #4
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00


STRAIN PATH #2A
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.84 gm/cc
Moisture Content: 0.85 %
BOX #15, SAMPLE #4
A
B
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
VOLUMETRIC STRAIN, %

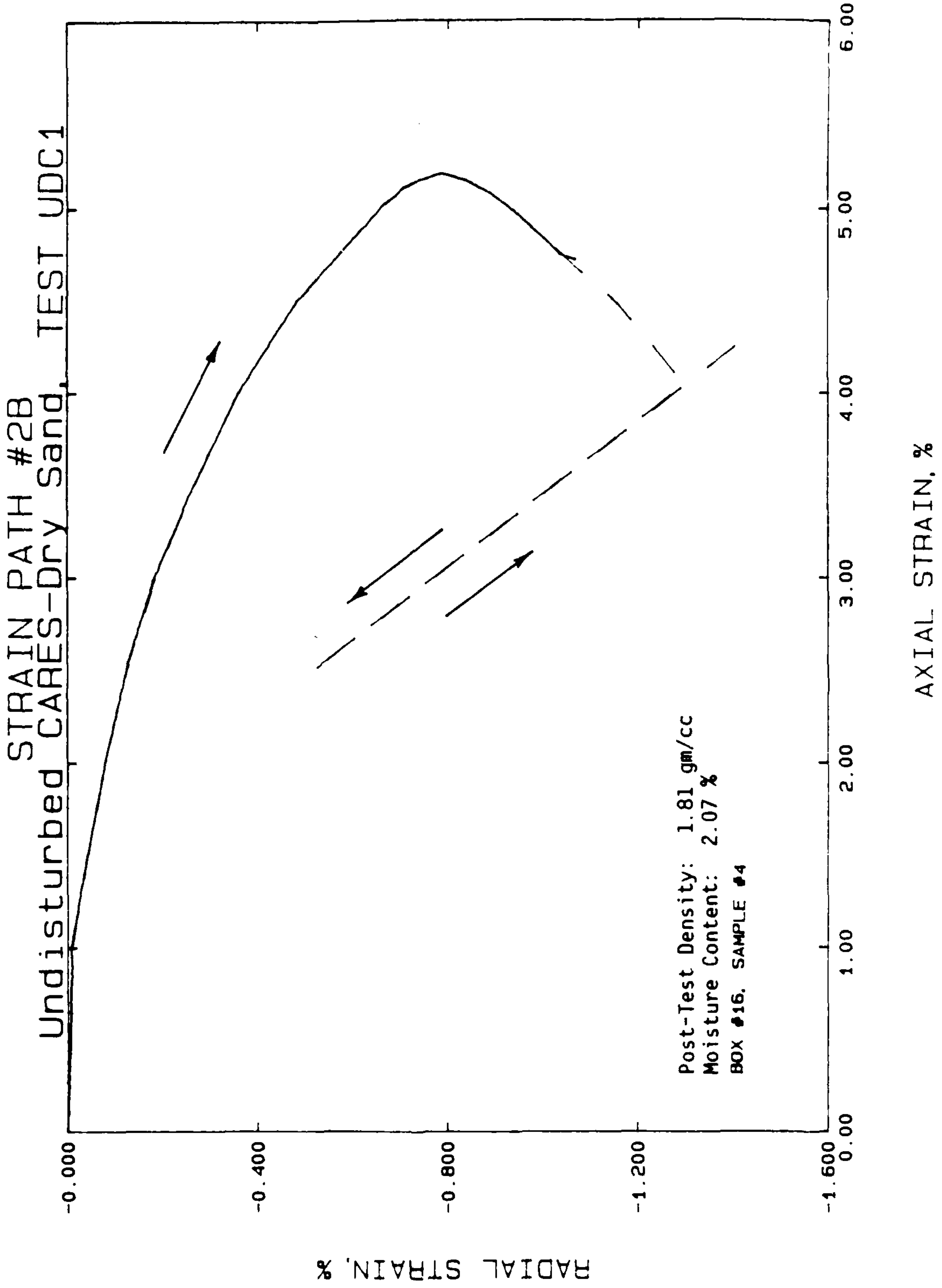

STRAIN PATH #2B
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.81 gm/cc
Moisture Content: 2.07 %
BOX #16, SAMPLE #4
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
-0.000
-0.400
-0.800
-1.200
-1.600

Plate 210

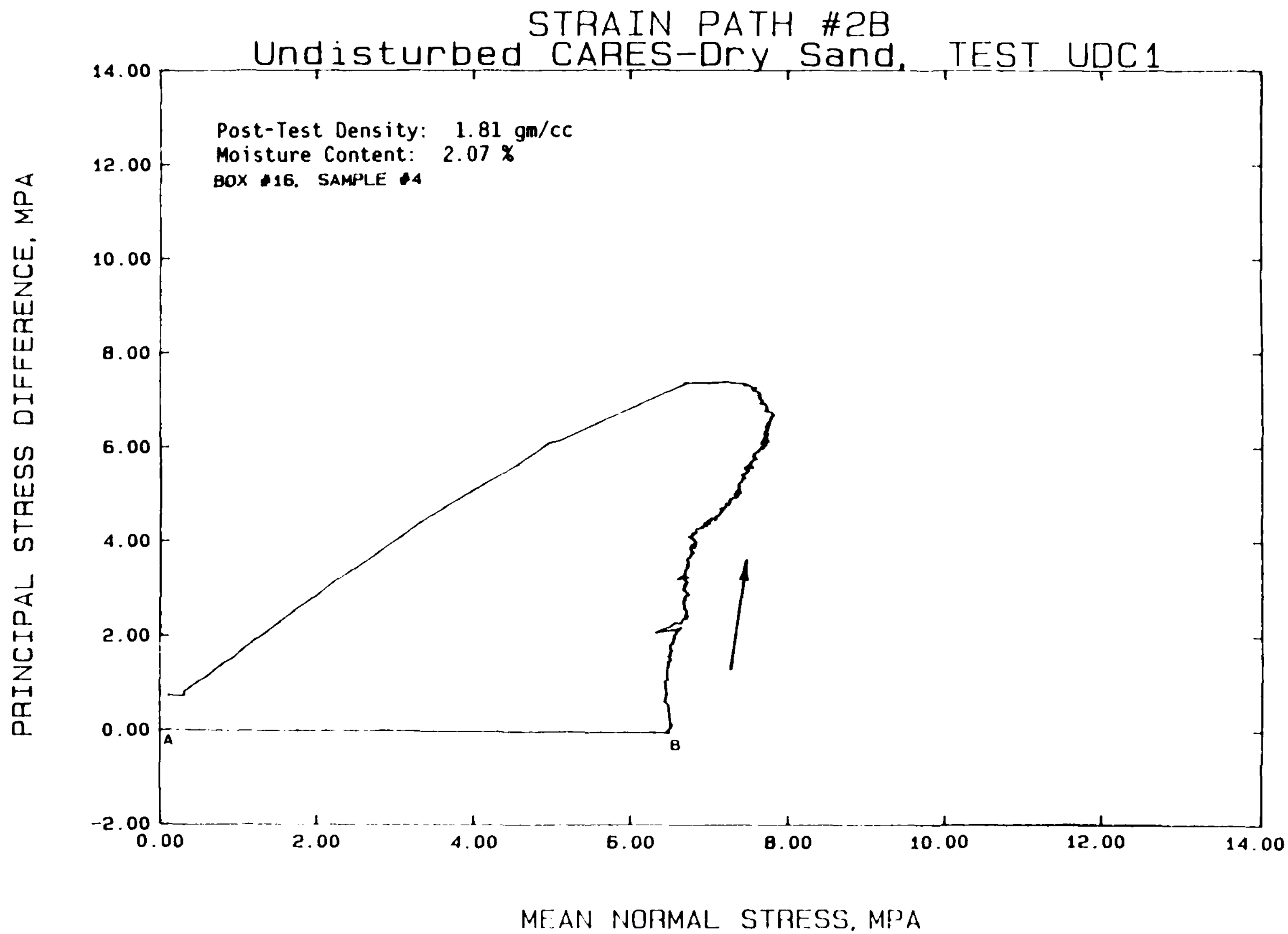

STRAIN PATH #2B
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.81 gm/cc
Moisture Content: 2.07 %
BOX #16, SAMPLE #4
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
A
B

Plate 211

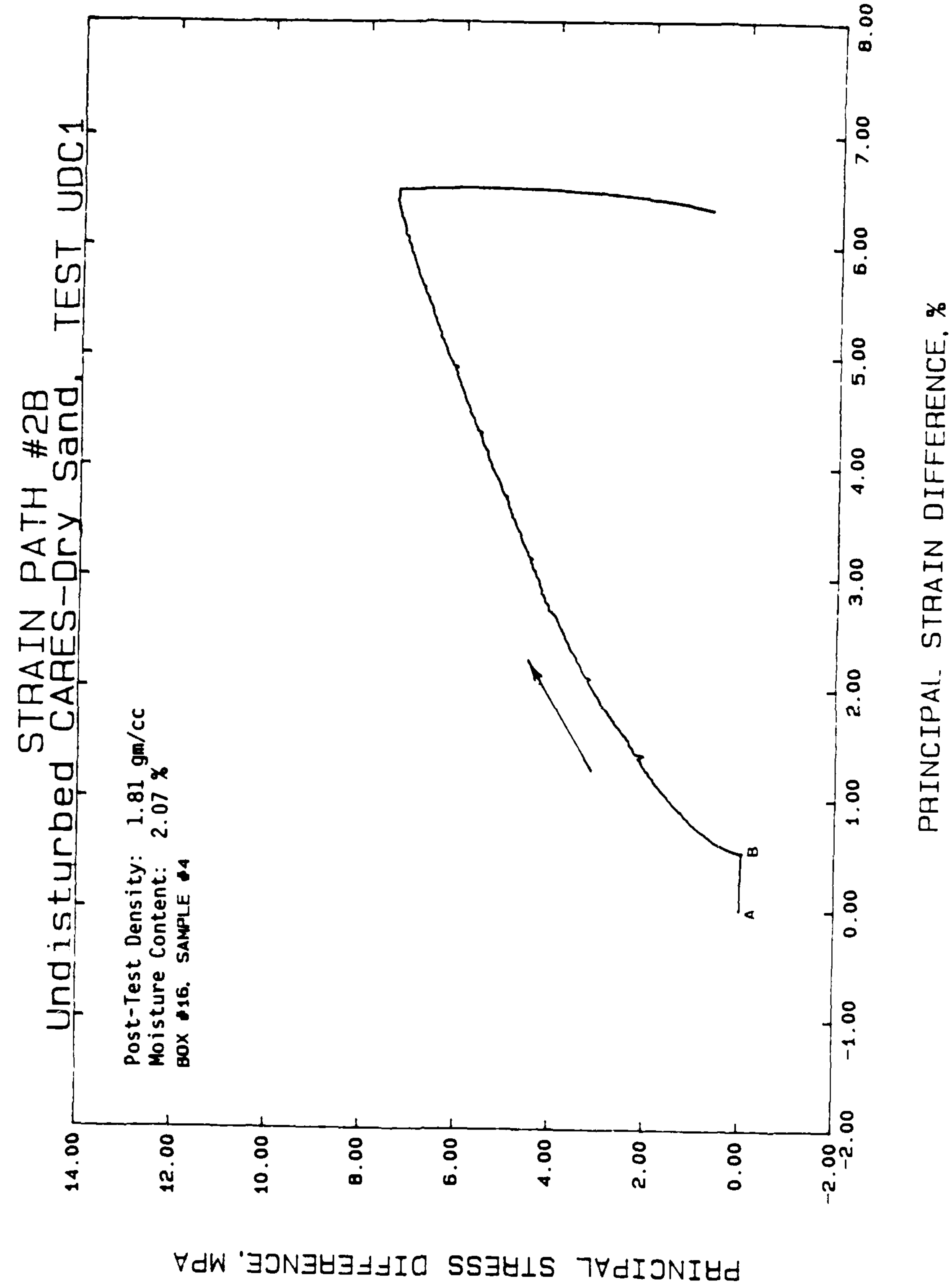

STRAIN PATH #2B
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.81 gm/cc
Moisture Content: 2.07 %
BOX #16, SAMPLE #4
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00

Plate 212

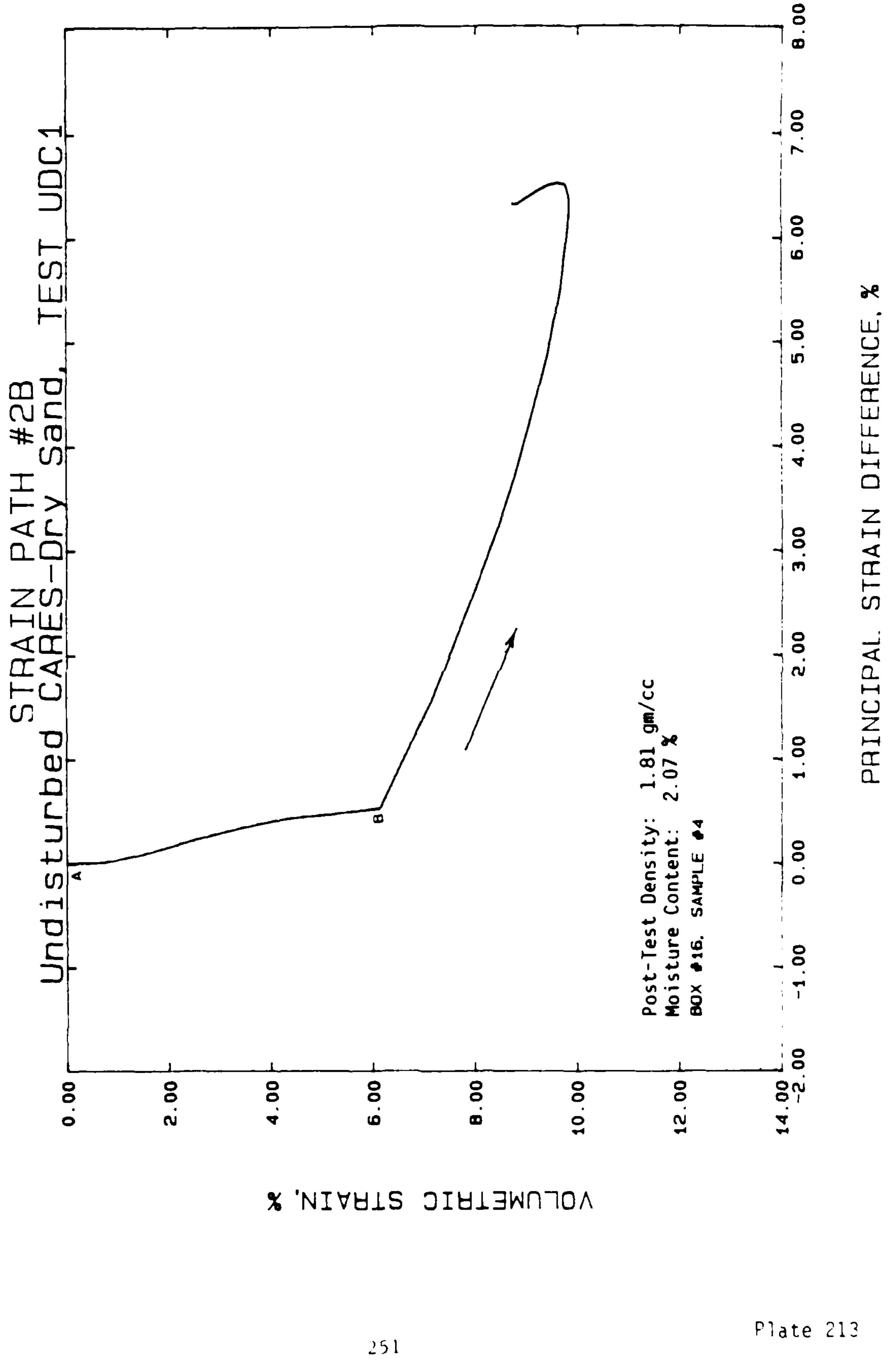
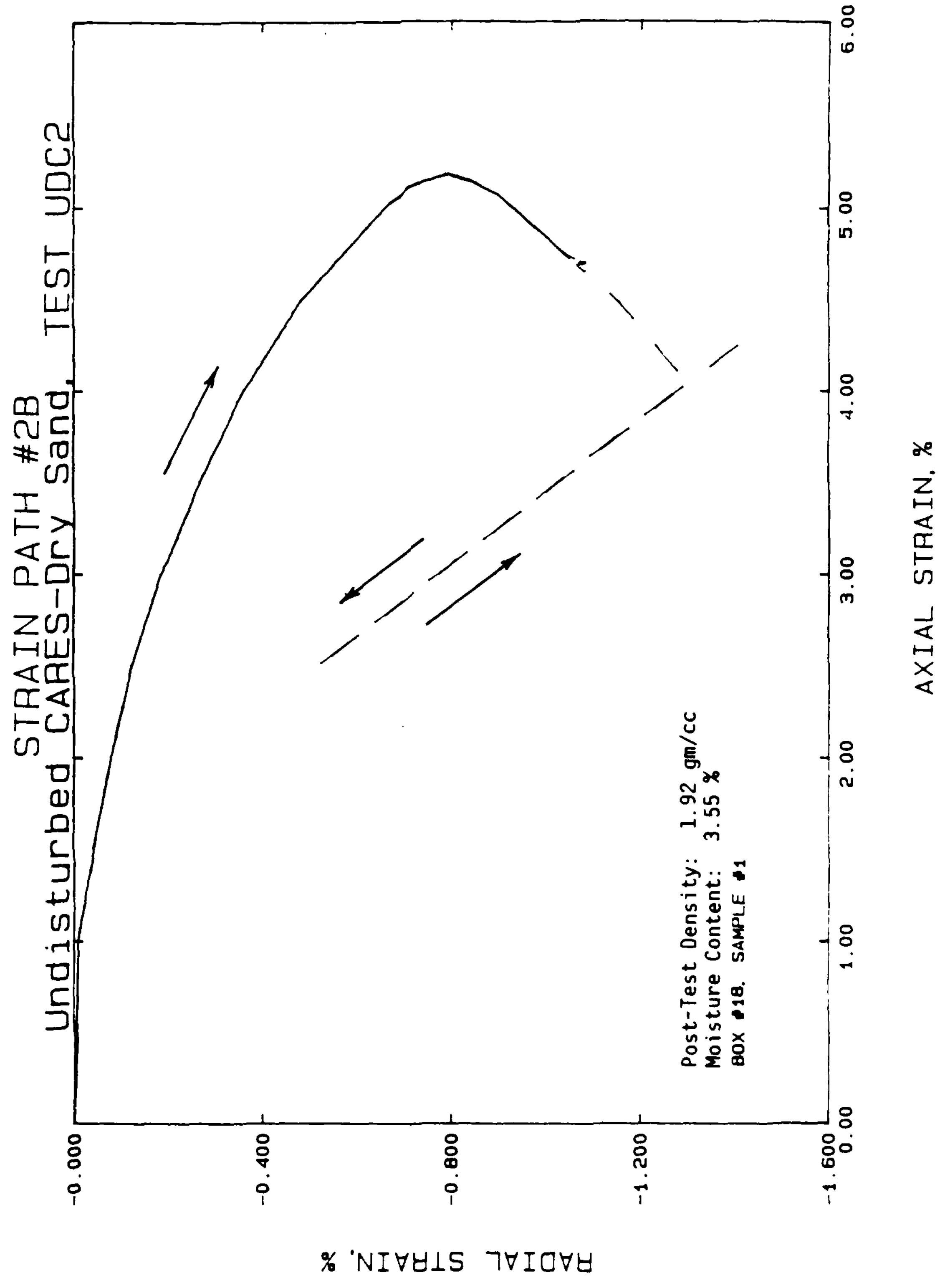
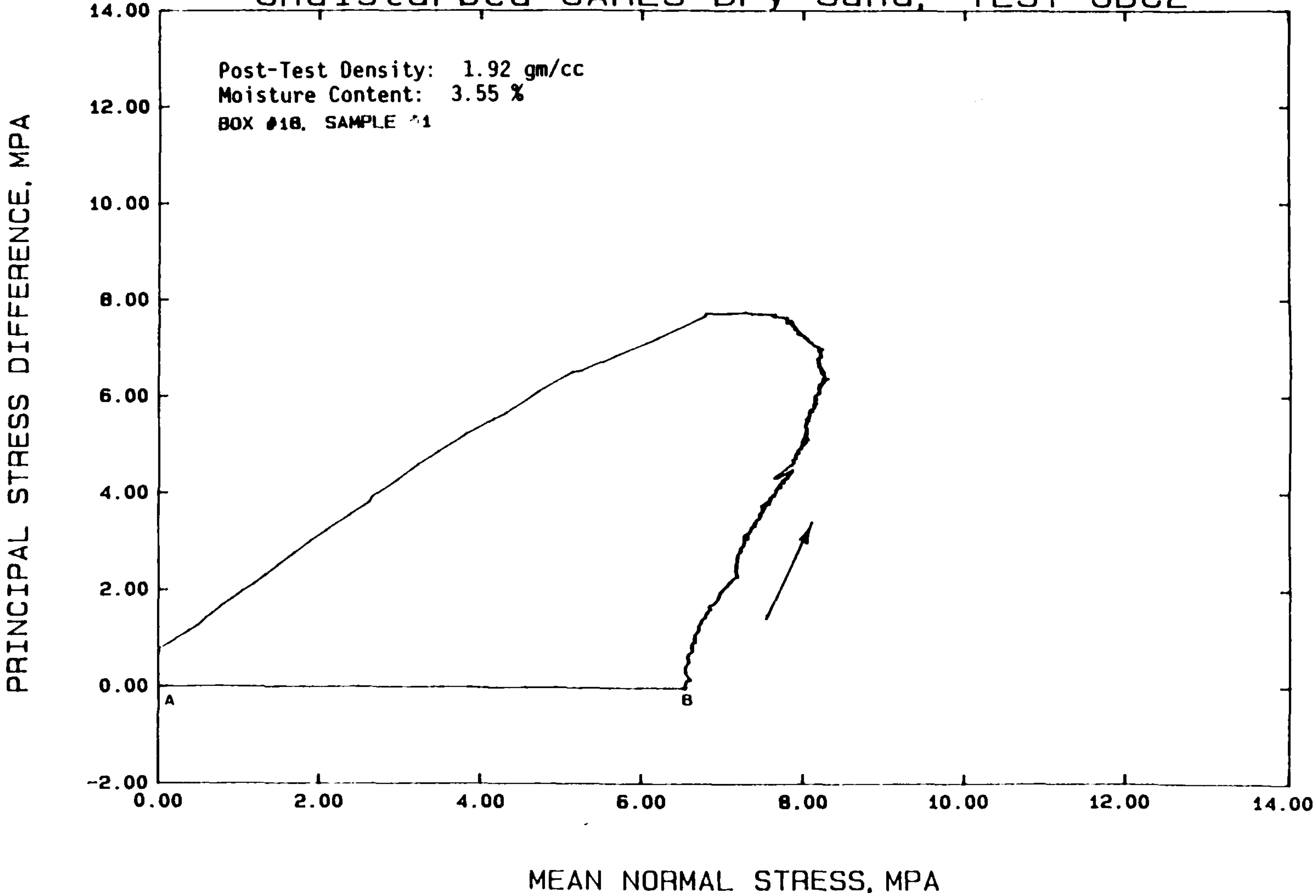

STRAIN PATH #2B
Undisturbed CARES-Dry Sand, TEST UDC1
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
A
B
Post-Test Density: 1.81 gm/cc
Moisture Content: 2.07 %
BOX #16, SAMPLE #4

Plate 213



STRAIN PATH #2B
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.92 gm/cc
Moisture Content: 3.55 %
BOX #18, SAMPLE #1
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
-0.000
-0.400
-0.800
-1.200
-1.600

STRAIN PATH #2B
Undisturbed CARES-Dry Sand, TEST UDC2



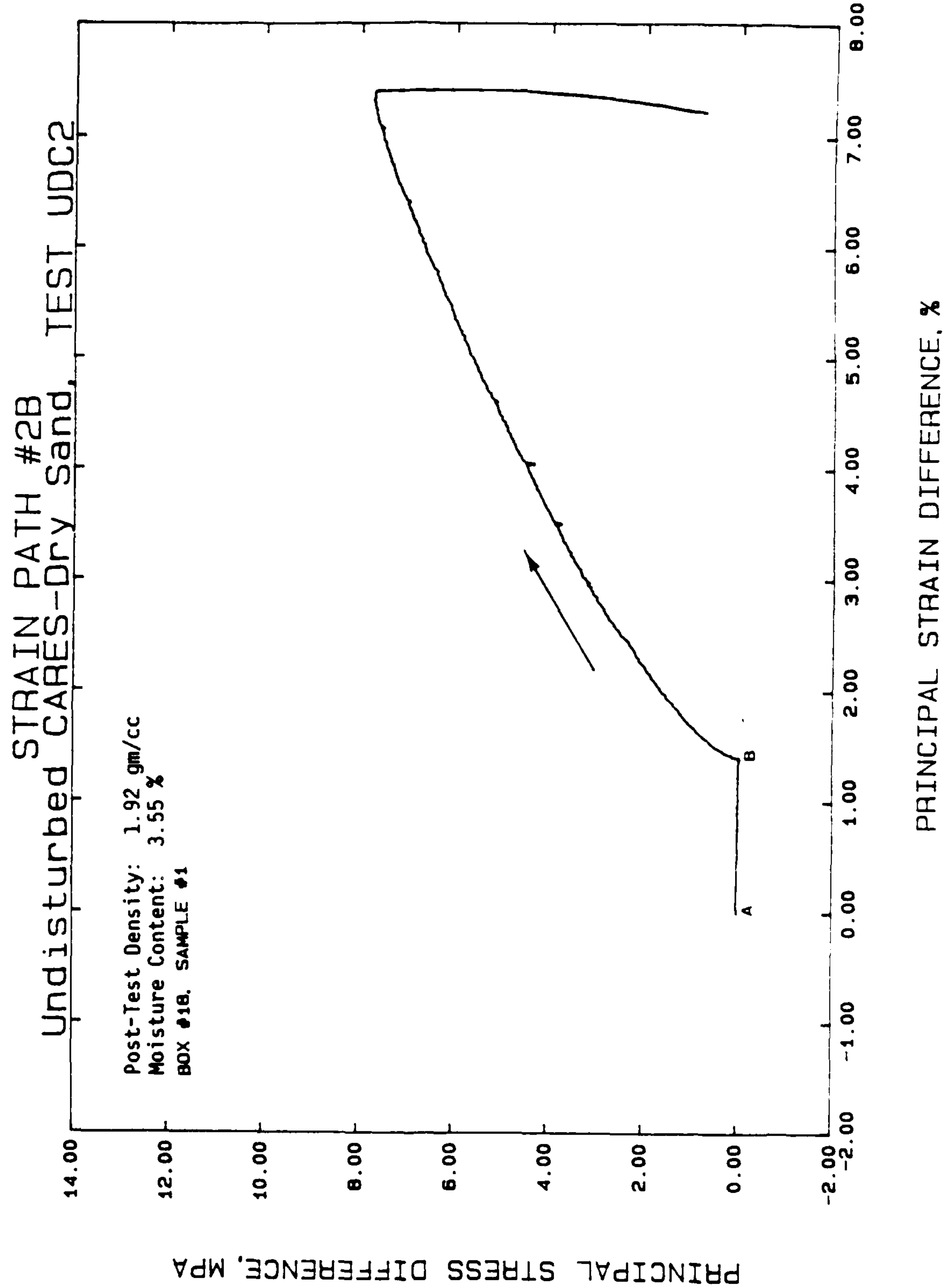
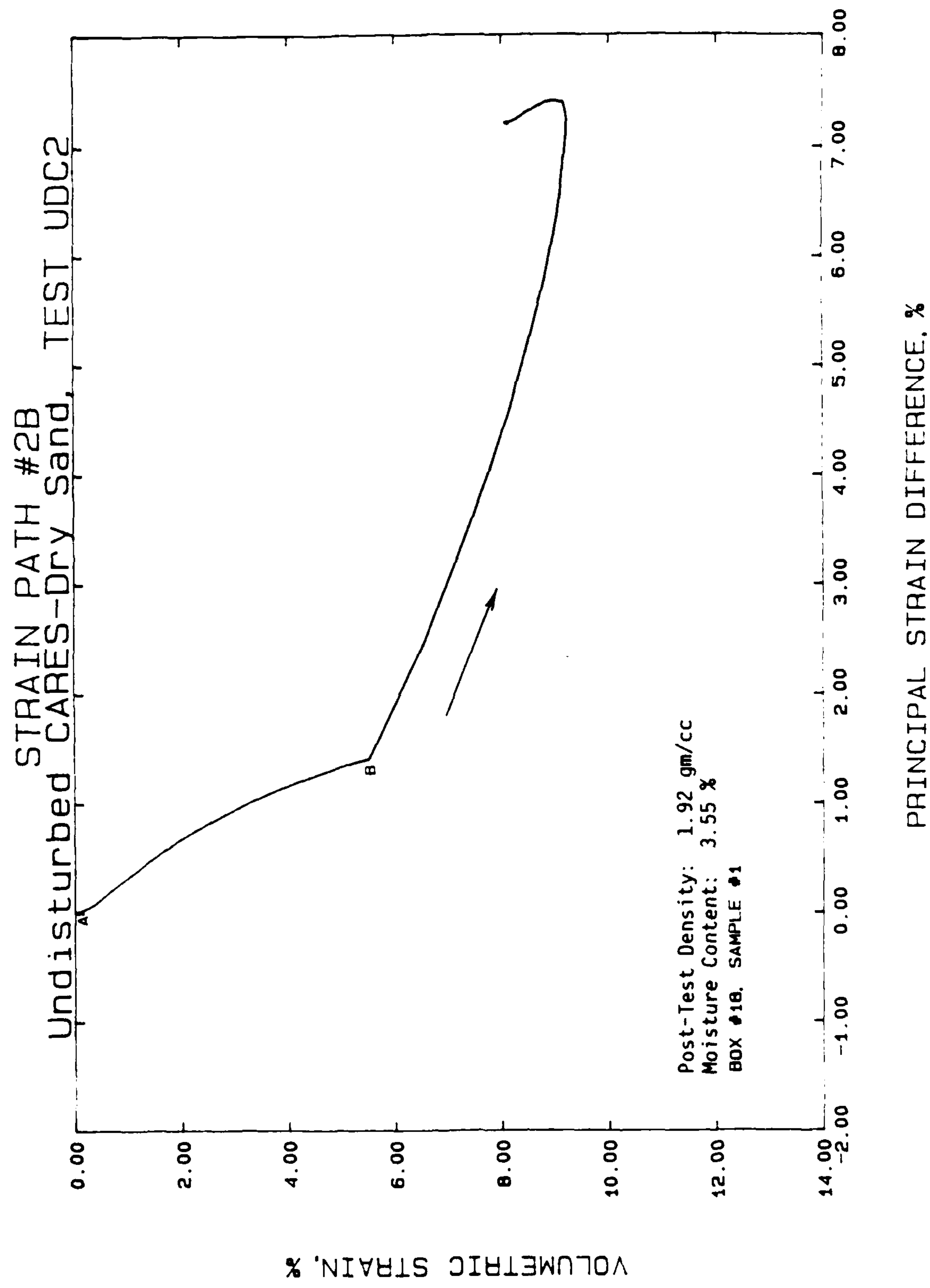
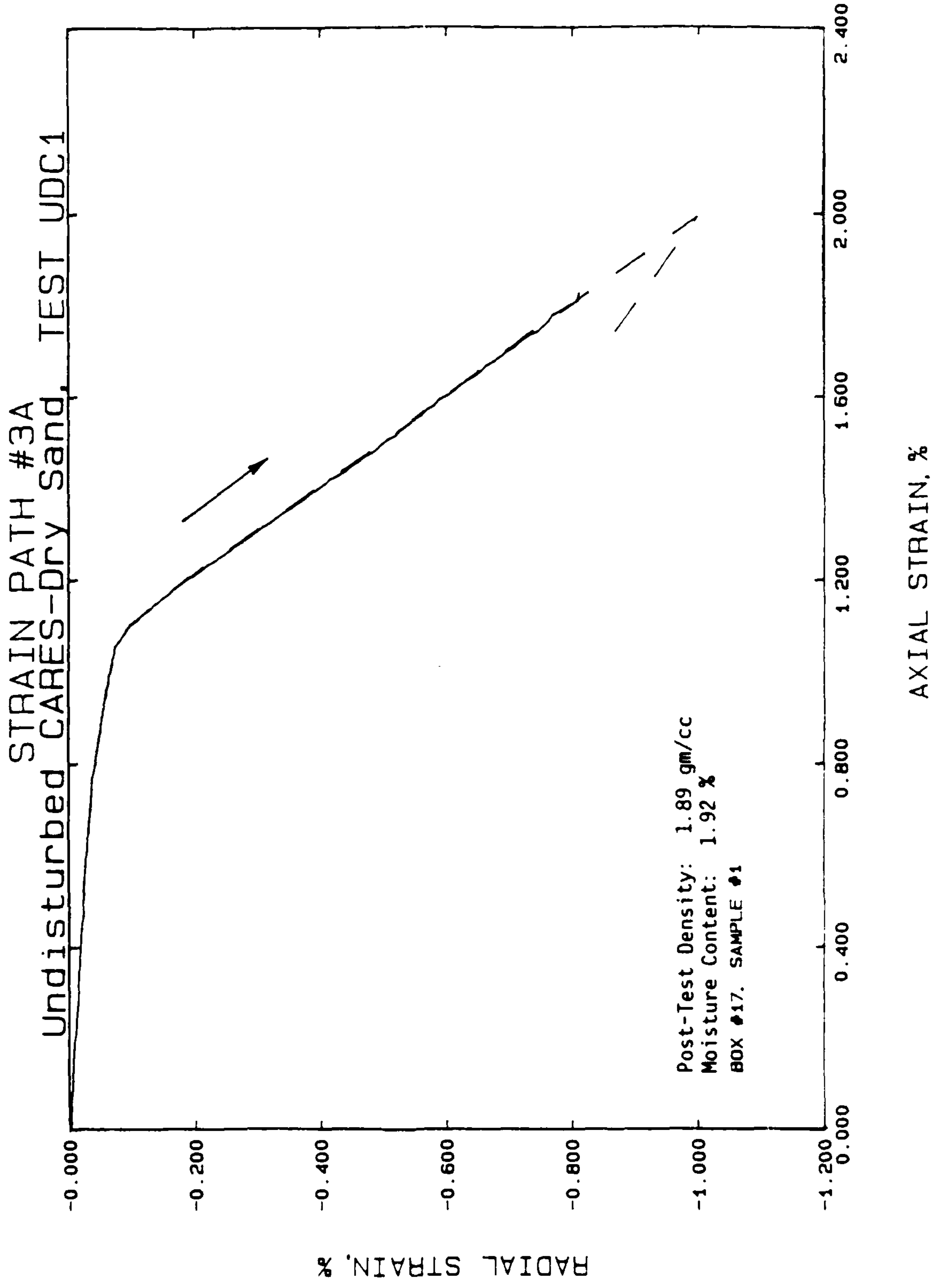

STRAIN PATH #2B
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.92 gm/cc
Moisture Content: 3.55 %
BOX #18, SAMPLE #1
A
B
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 216



STRAIN PATH #2B
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.92 gm/cc
Moisture Content: 3.55 %
BOX #18, SAMPLE #1
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %

Plate 217


STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.89 gm/cc
Moisture Content: 1.92 %
BOX #17, SAMPLE #1
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200

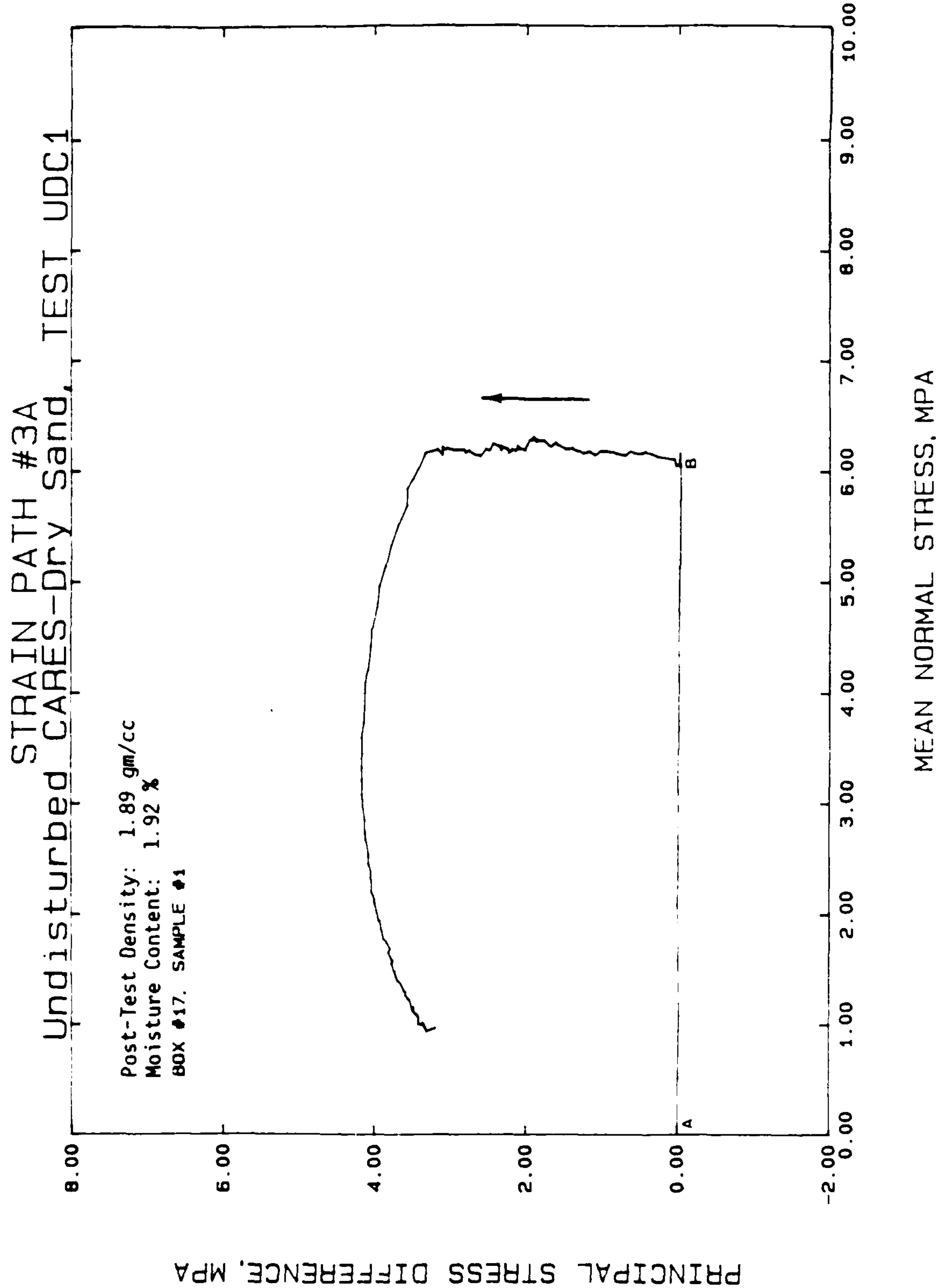
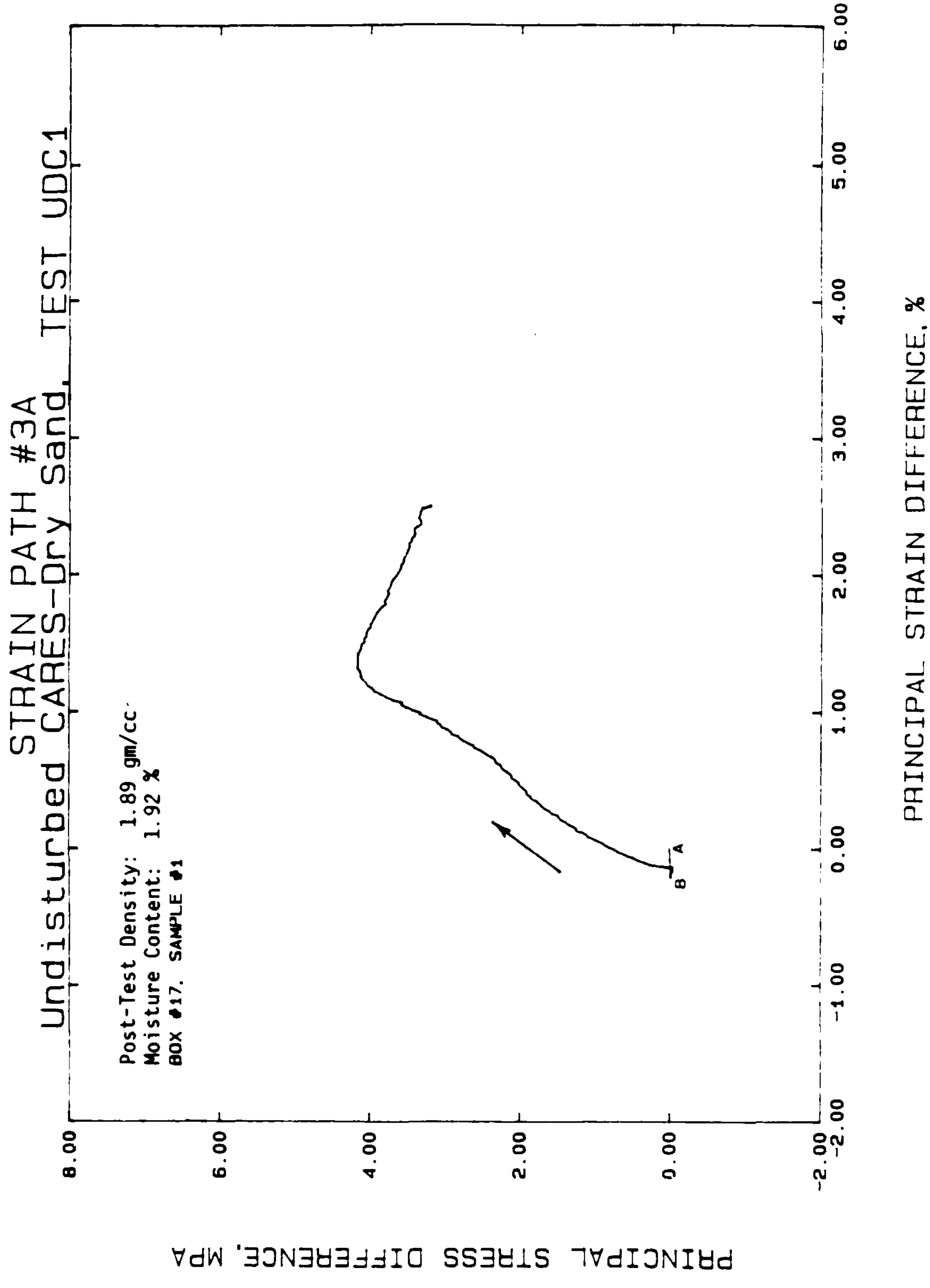
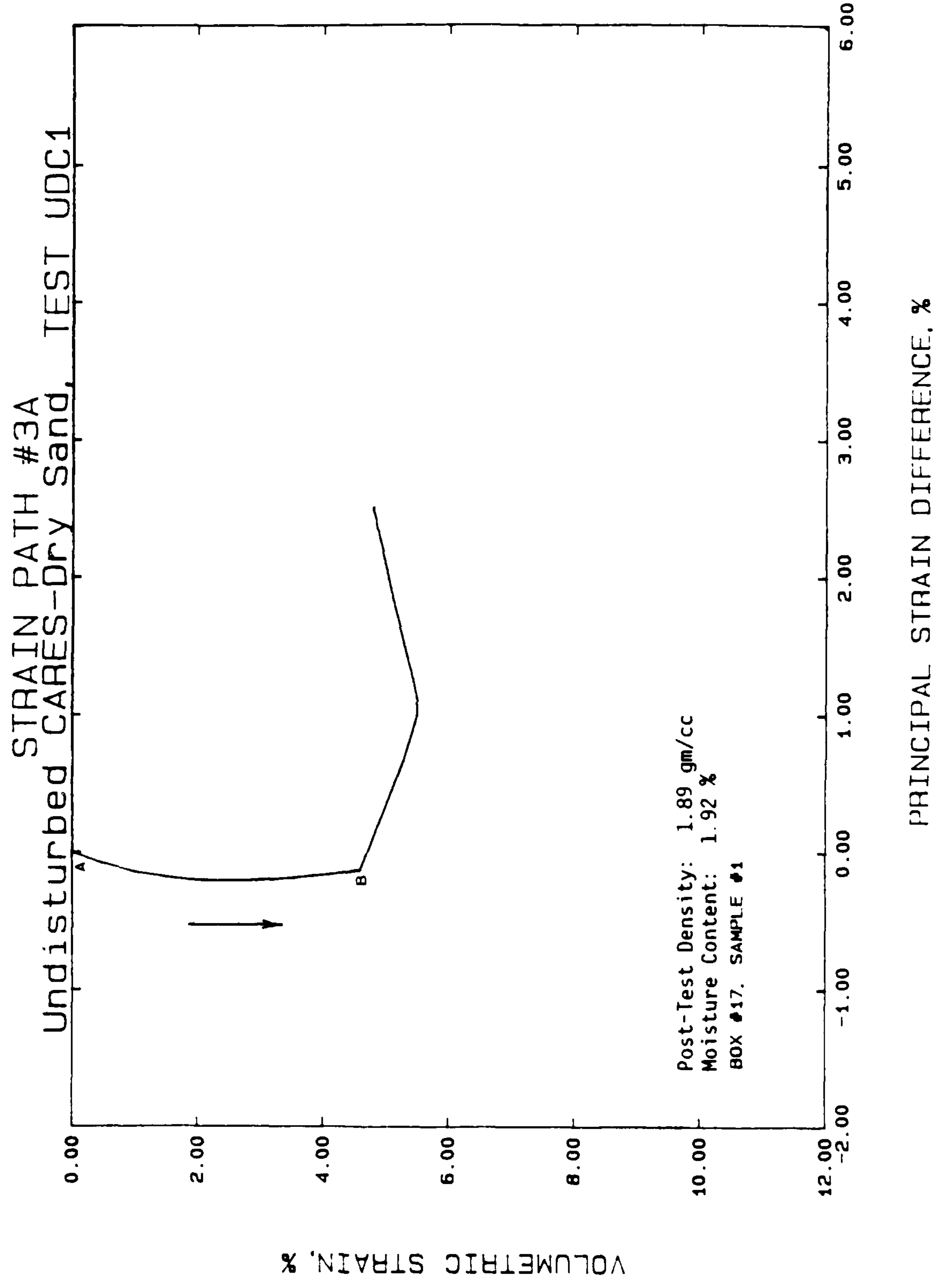

STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.89 gm/cc
Moisture Content: 1.92 %
BOX #17. SAMPLE #1
A
B
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
MEAN NORMAL STRESS, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 219



STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.89 gm/cc
Moisture Content: 1.92 %
BOX #17, SAMPLE #1
A
B
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 220


STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.89 gm/cc
Moisture Content: 1.92 %
BOX #17, SAMPLE #1
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %

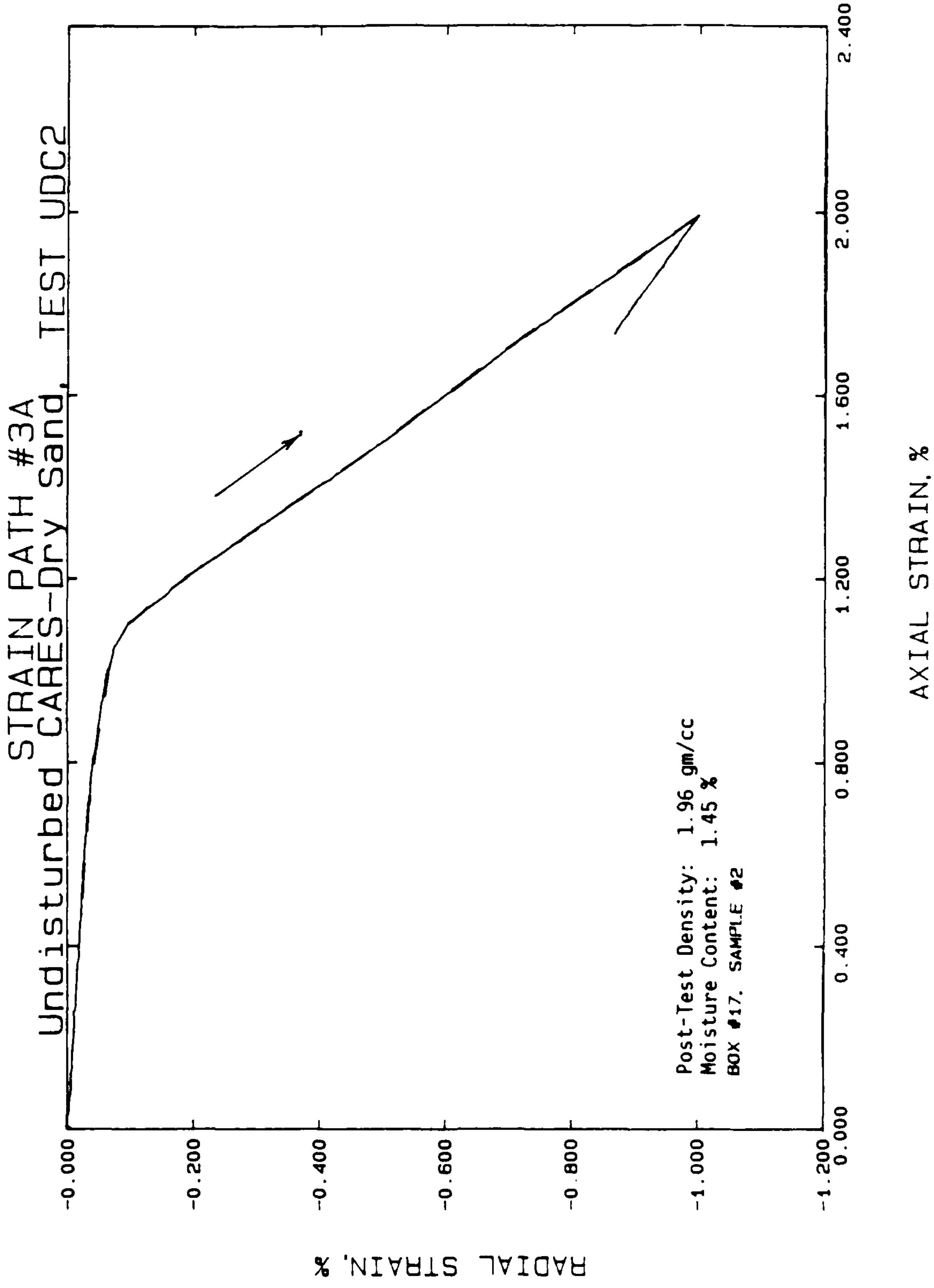
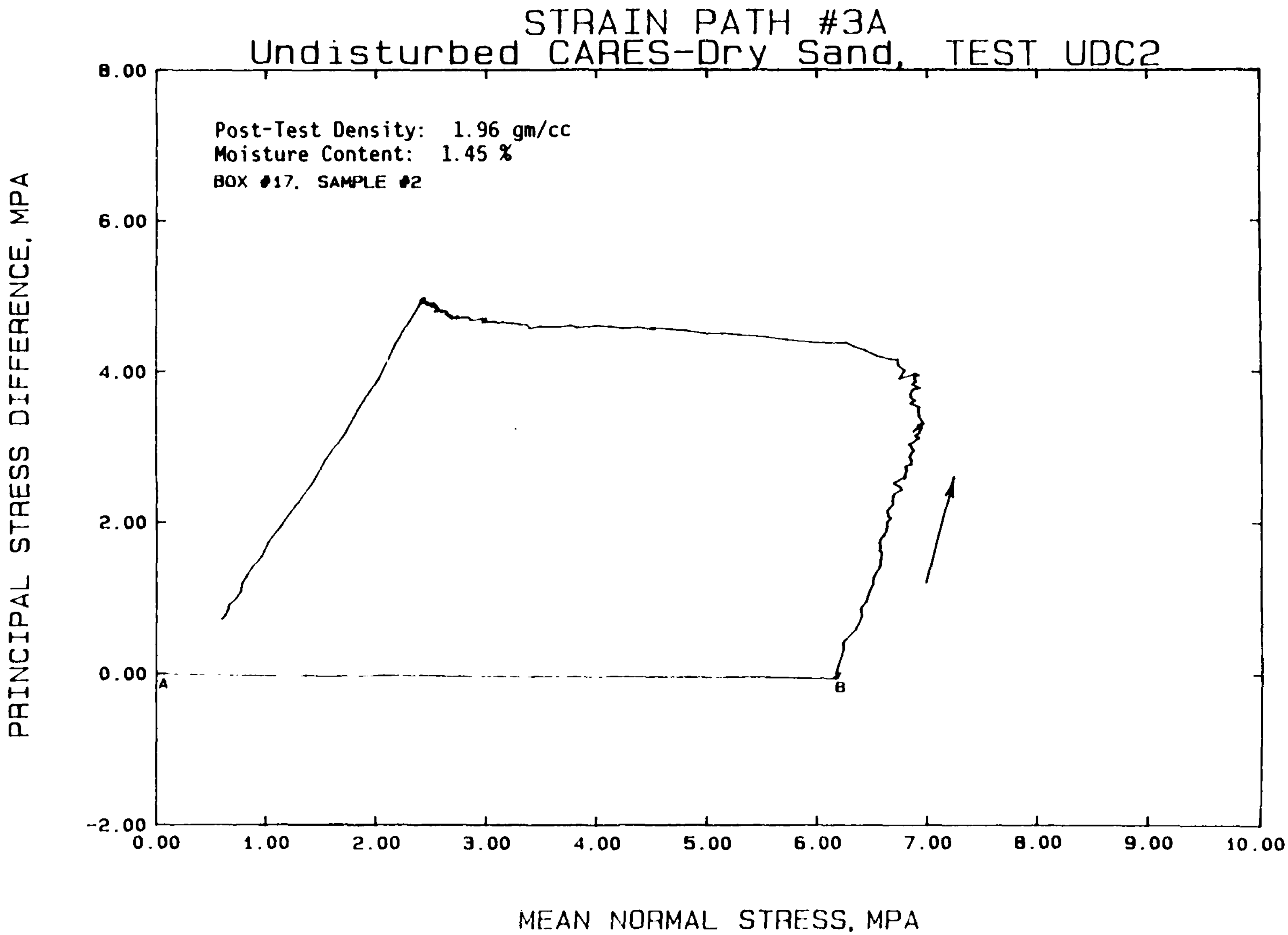
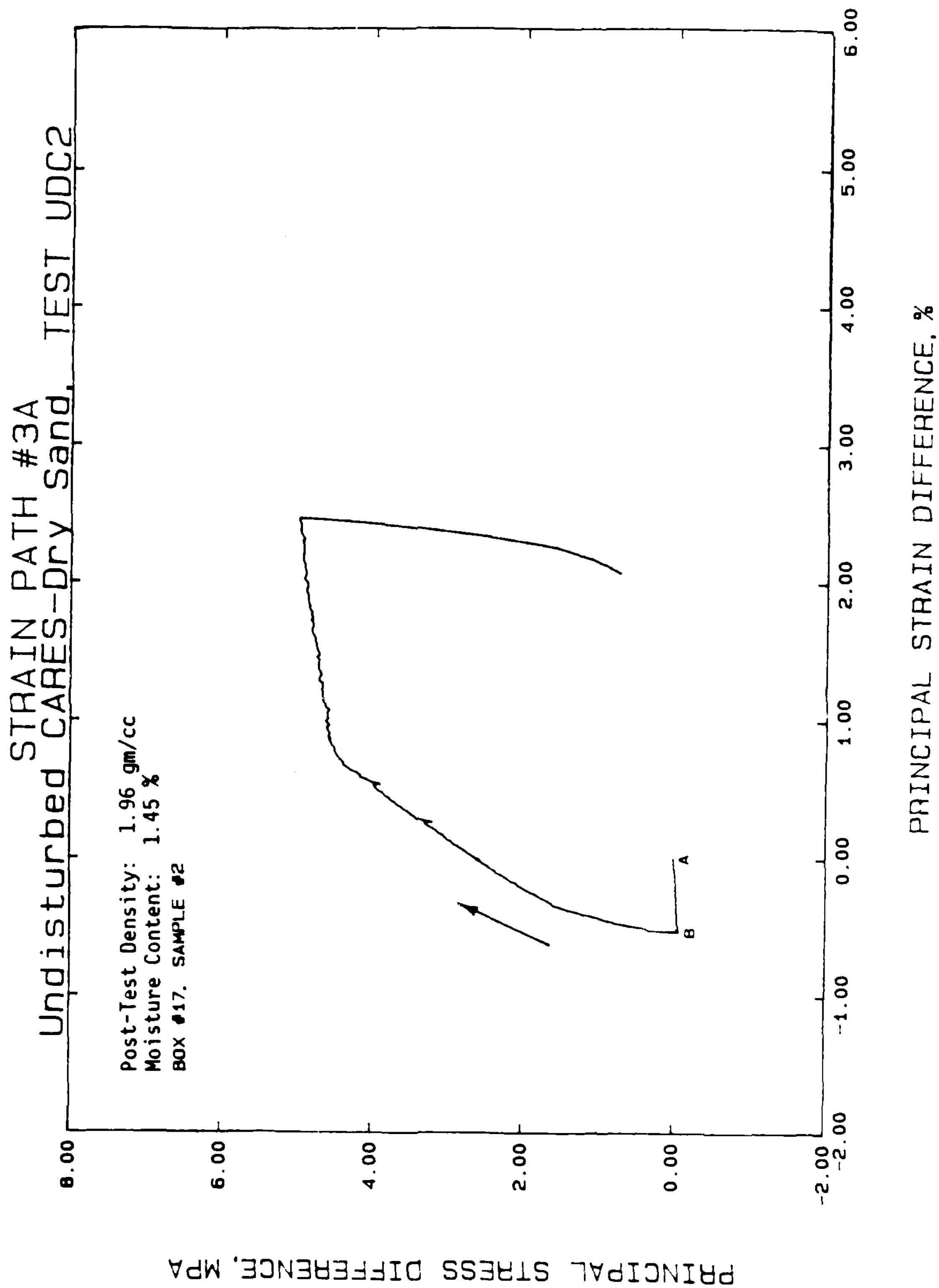

STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.96 gm/cc
Moisture Content: 1.45 %
BOX #17, SAMPLE #2
RADIAL STRAIN, %
AXIAL STRAIN, %
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200
0.000
0.400
0.800
1.200
1.600
2.000
2.400

Plate 222



STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.96 gm/cc
Moisture Content: 1.45 %
BOX #17, SAMPLE #2
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
A
B


STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.96 gm/cc
Moisture Content: 1.45 %
BOX #17, SAMPLE #2
A
B
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %

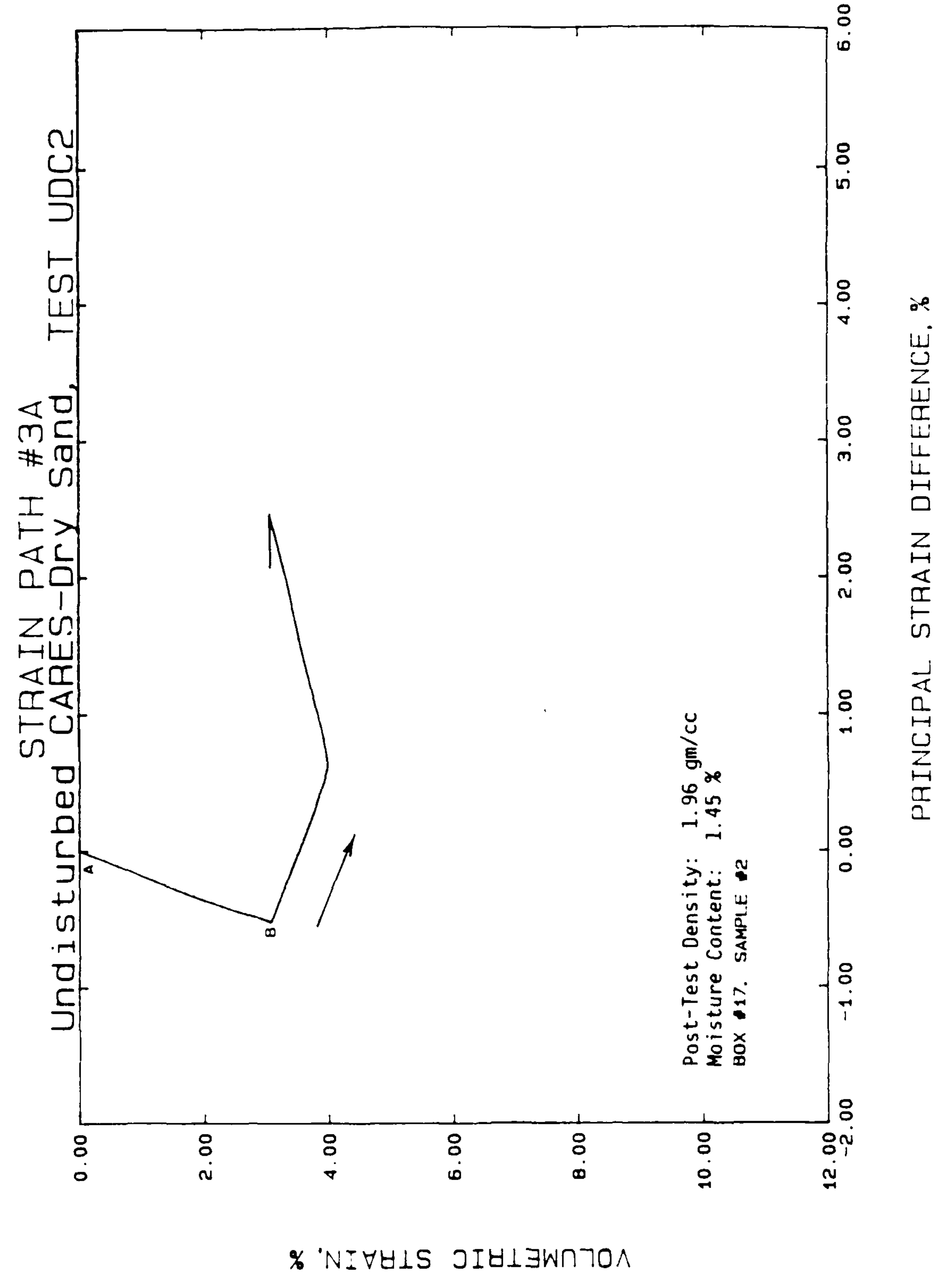
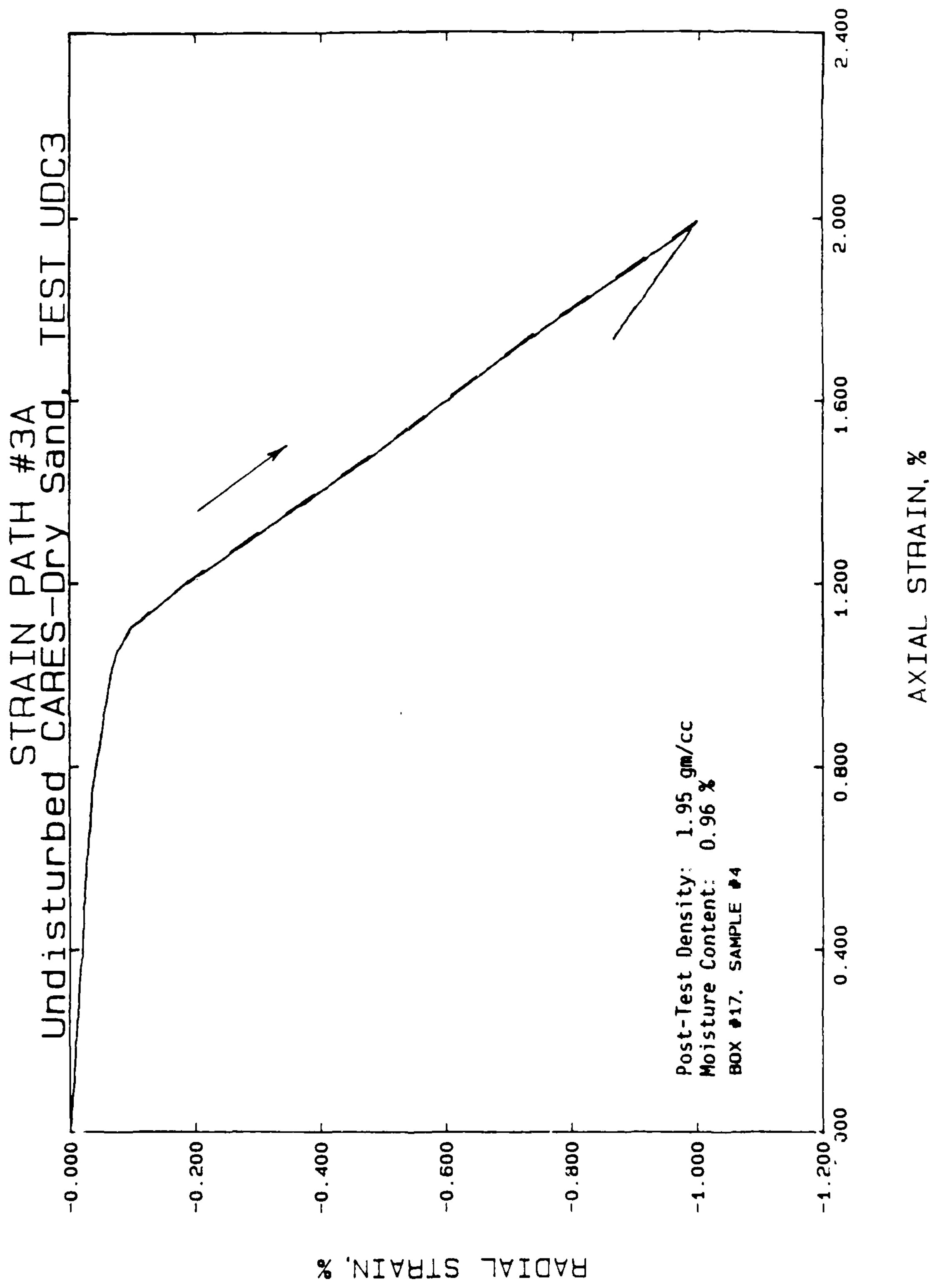

STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.96 gm/cc
Moisture Content: 1.45 %
BOX #17, SAMPLE #2
A
B
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %

Plate 225



STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.95 gm/cc
Moisture Content: 0.96 %
BOX #17, SAMPLE #4
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200

Plate 226

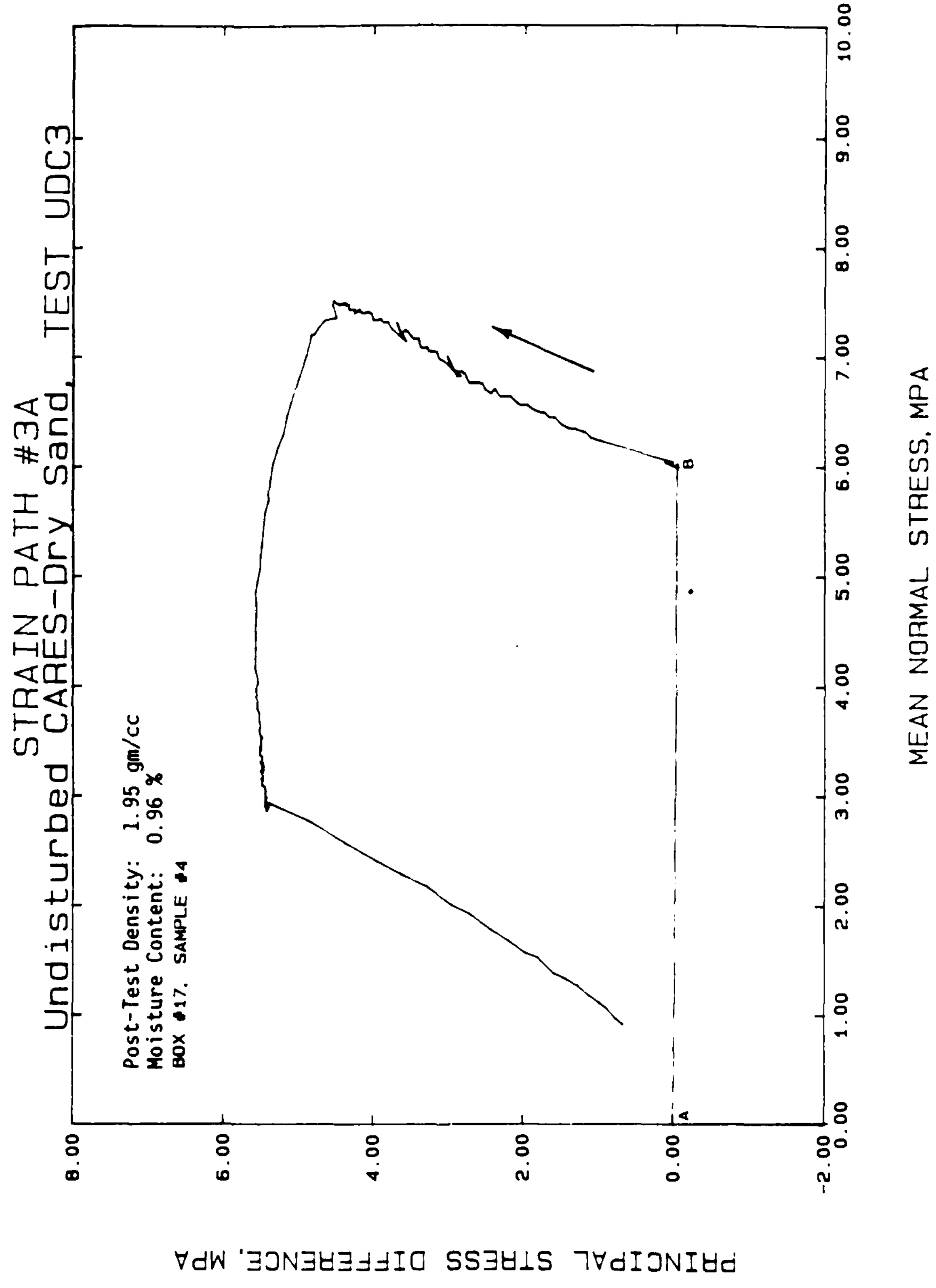

STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.95 gm/cc
Moisture Content: 0.96 %
BOX #17, SAMPLE #4
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
MEAN NORMAL STRESS, MPA
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00

Plate 227

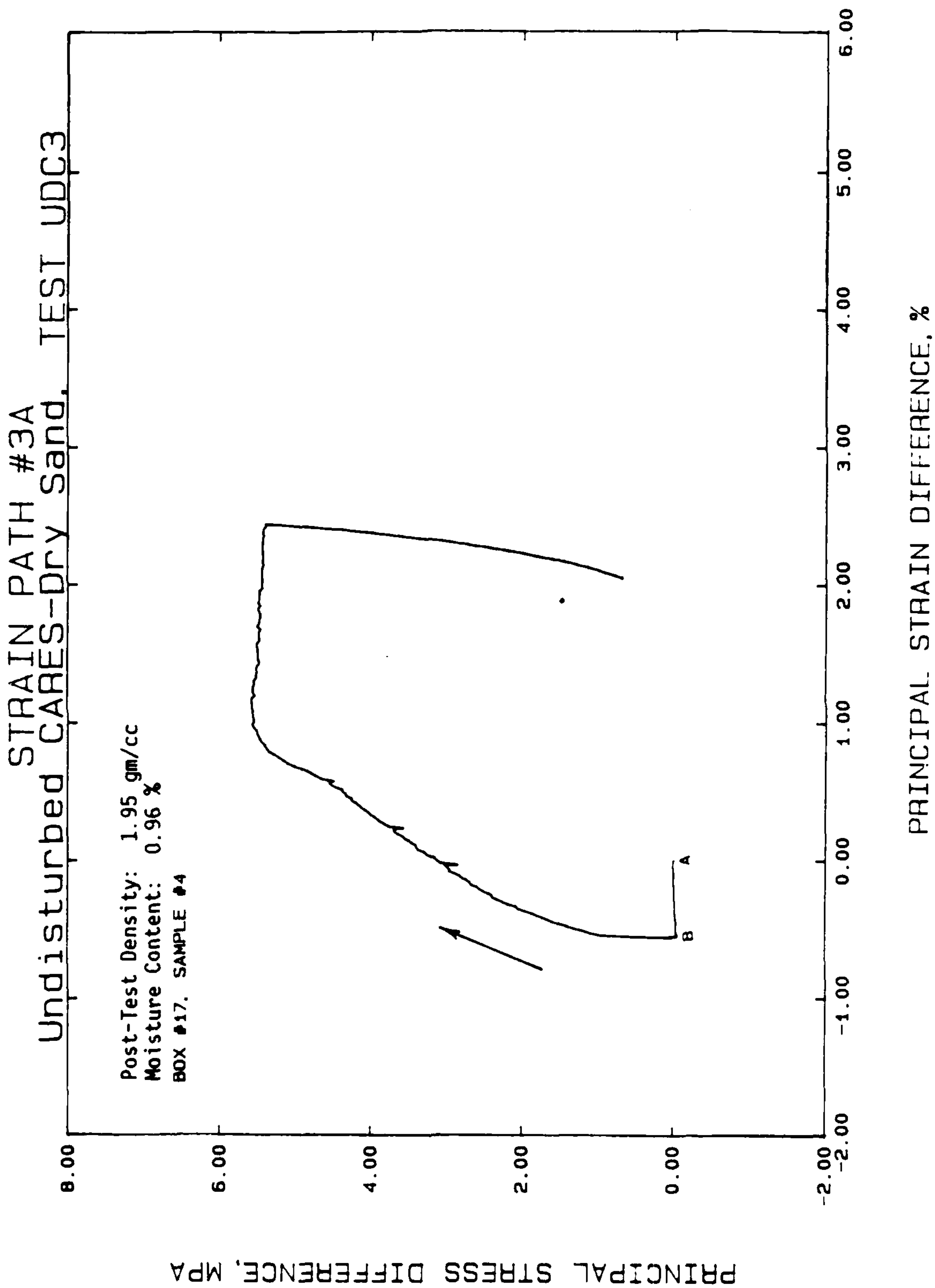
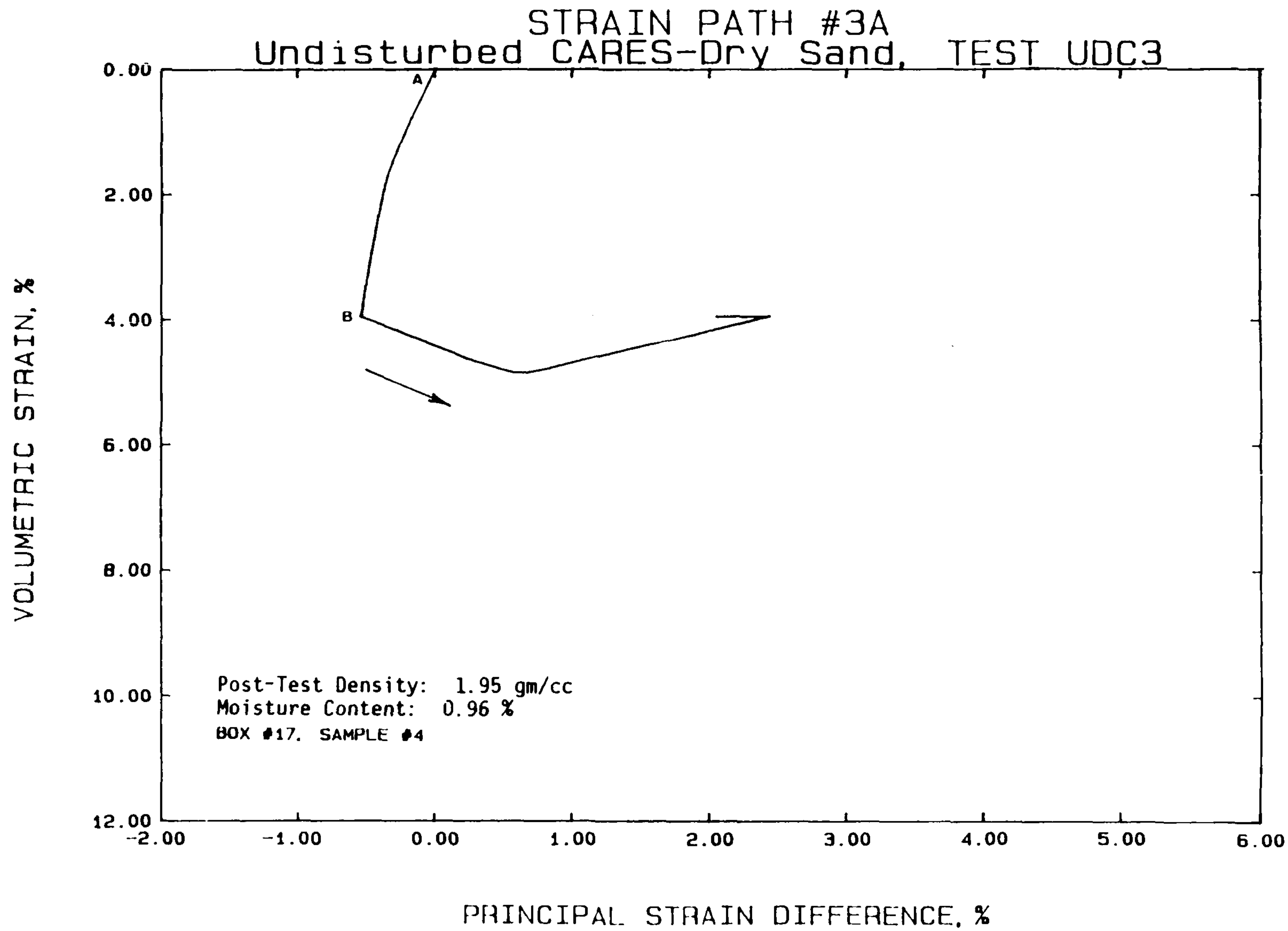

STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.95 gm/cc
Moisture Content: 0.96 %
BOX #17, SAMPLE #4
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
8.00
6.00
4.00
2.00
0.00
-2.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00

Plate 228


STRAIN PATH #3A
Undisturbed CARES-Dry Sand, TEST UDC3
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %
A
B
Post-Test Density: 1.95 gm/cc
Moisture Content: 0.96 %
BOX #17, SAMPLE #4

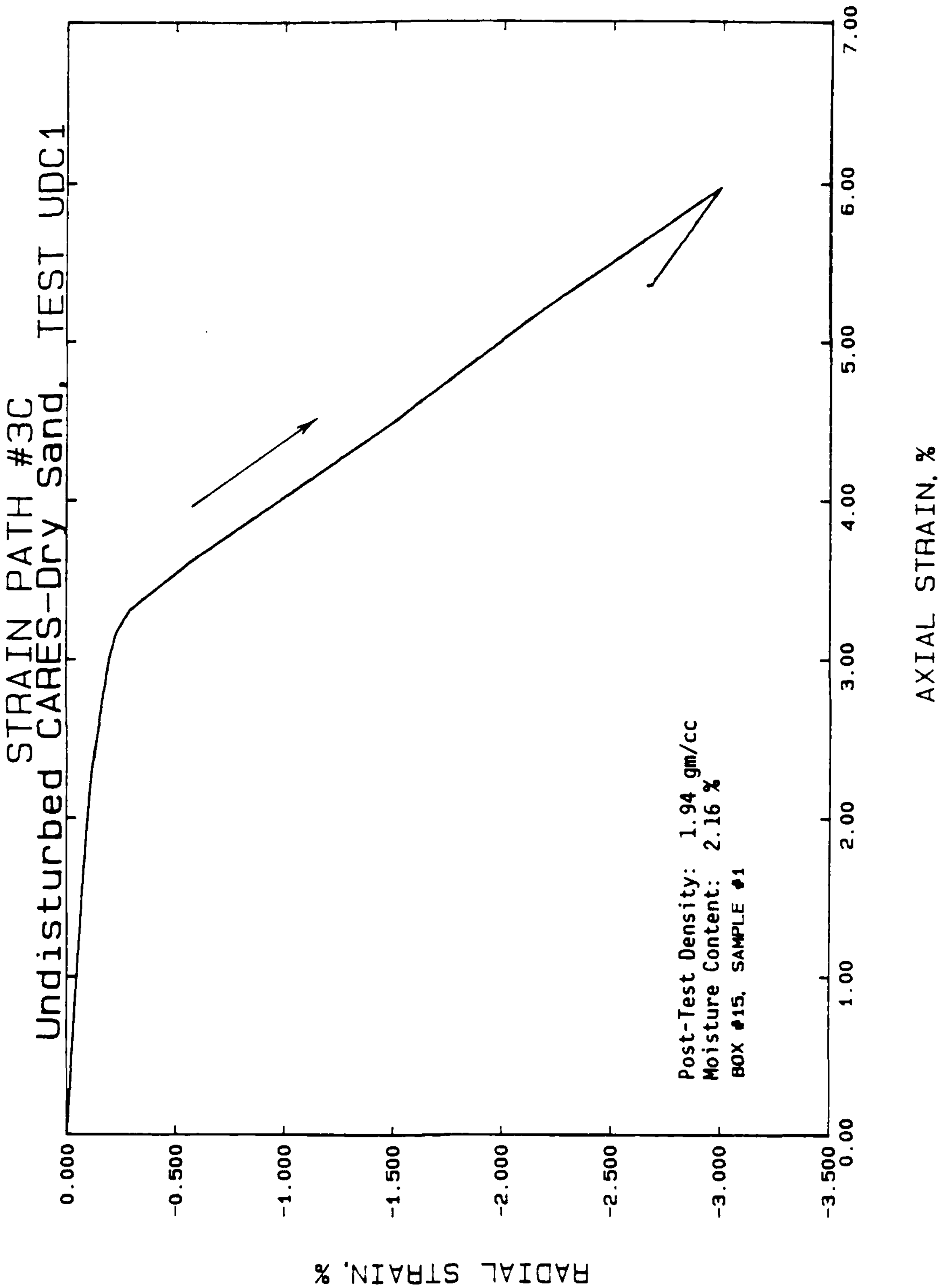
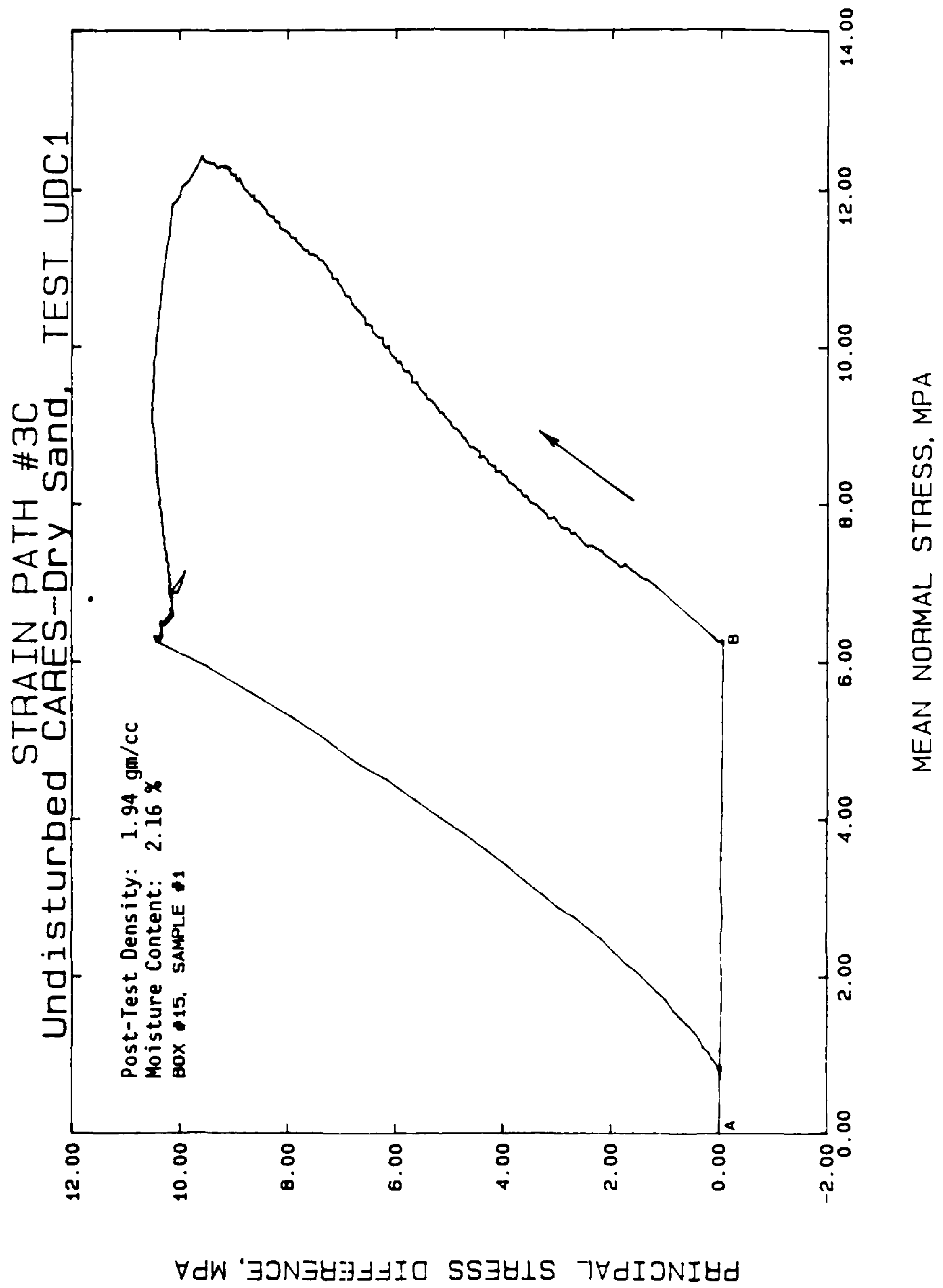

STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.94 gm/cc
Moisture Content: 2.16 %
BOX #15, SAMPLE #1
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
-3.500

Plate 230



STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.94 gm/cc
Moisture Content: 2.16 %
BOX #15, SAMPLE #1
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 231

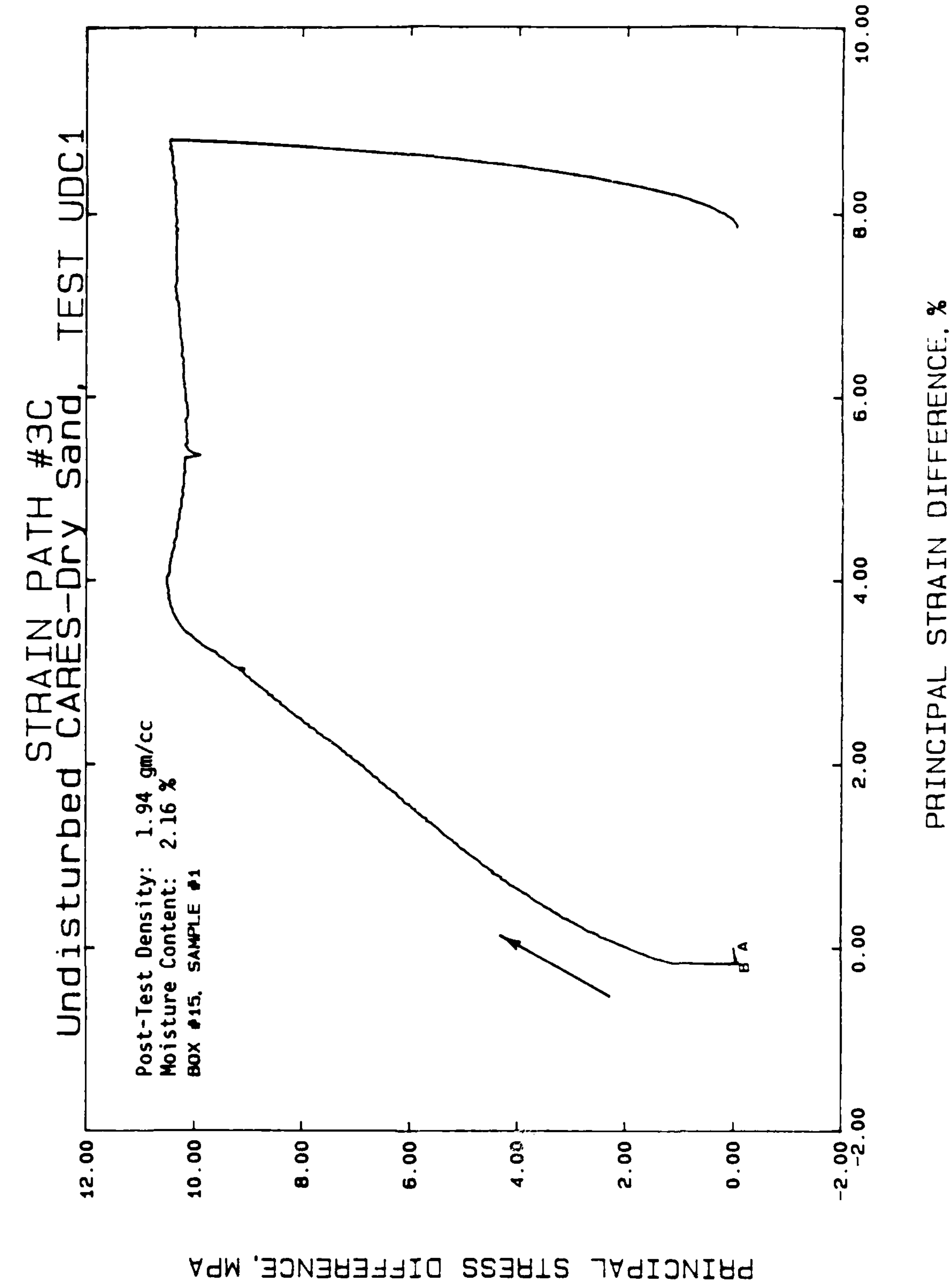
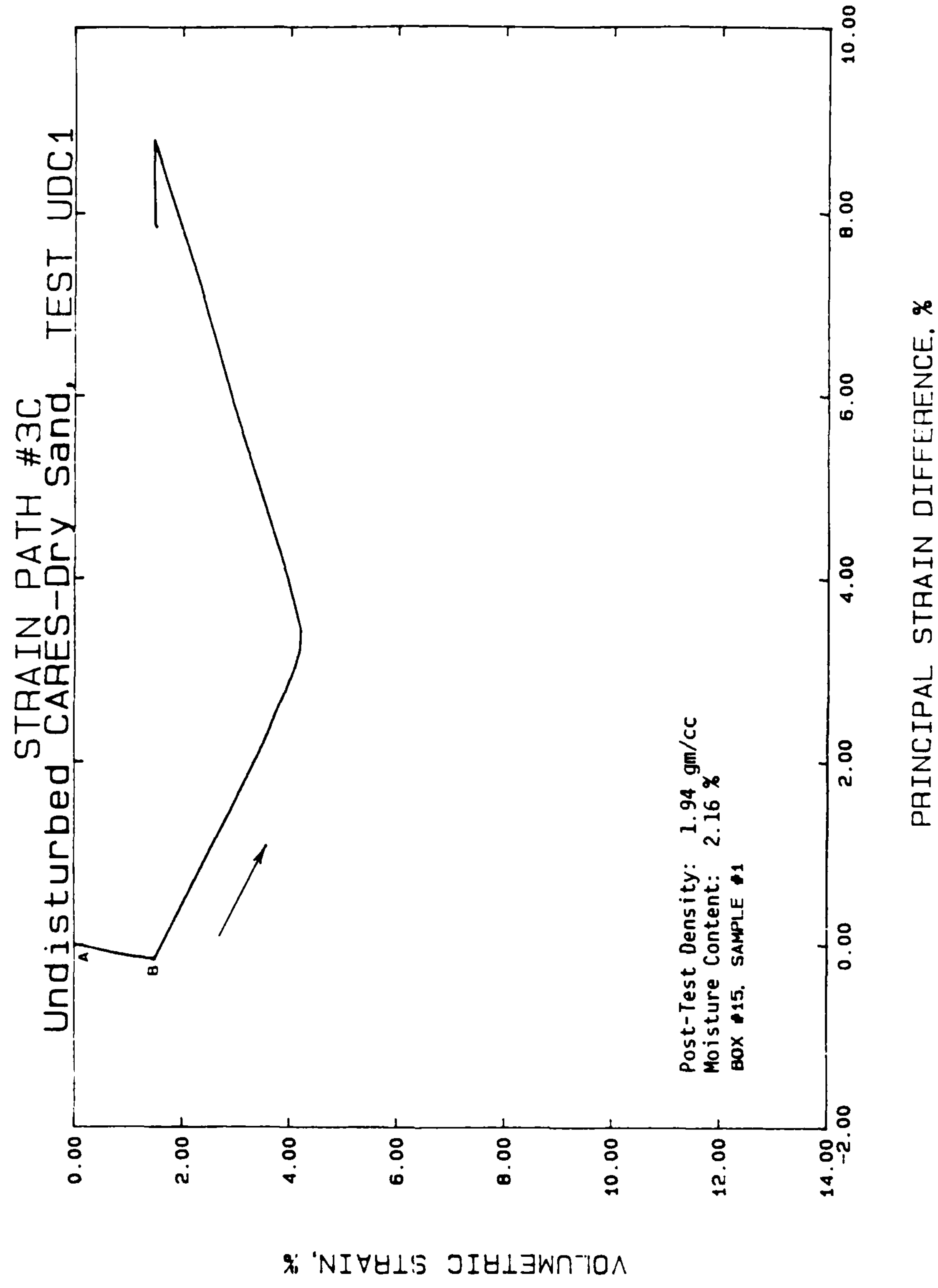

STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.94 gm/cc
Moisture Content: 2.16 %
BOX #15, SAMPLE #1
A
B
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %

Plate 232



STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC1
Post-Test Density: 1.94 gm/cc
Moisture Content: 2.16 %
BOX #15, SAMPLE #1
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 233

STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC2

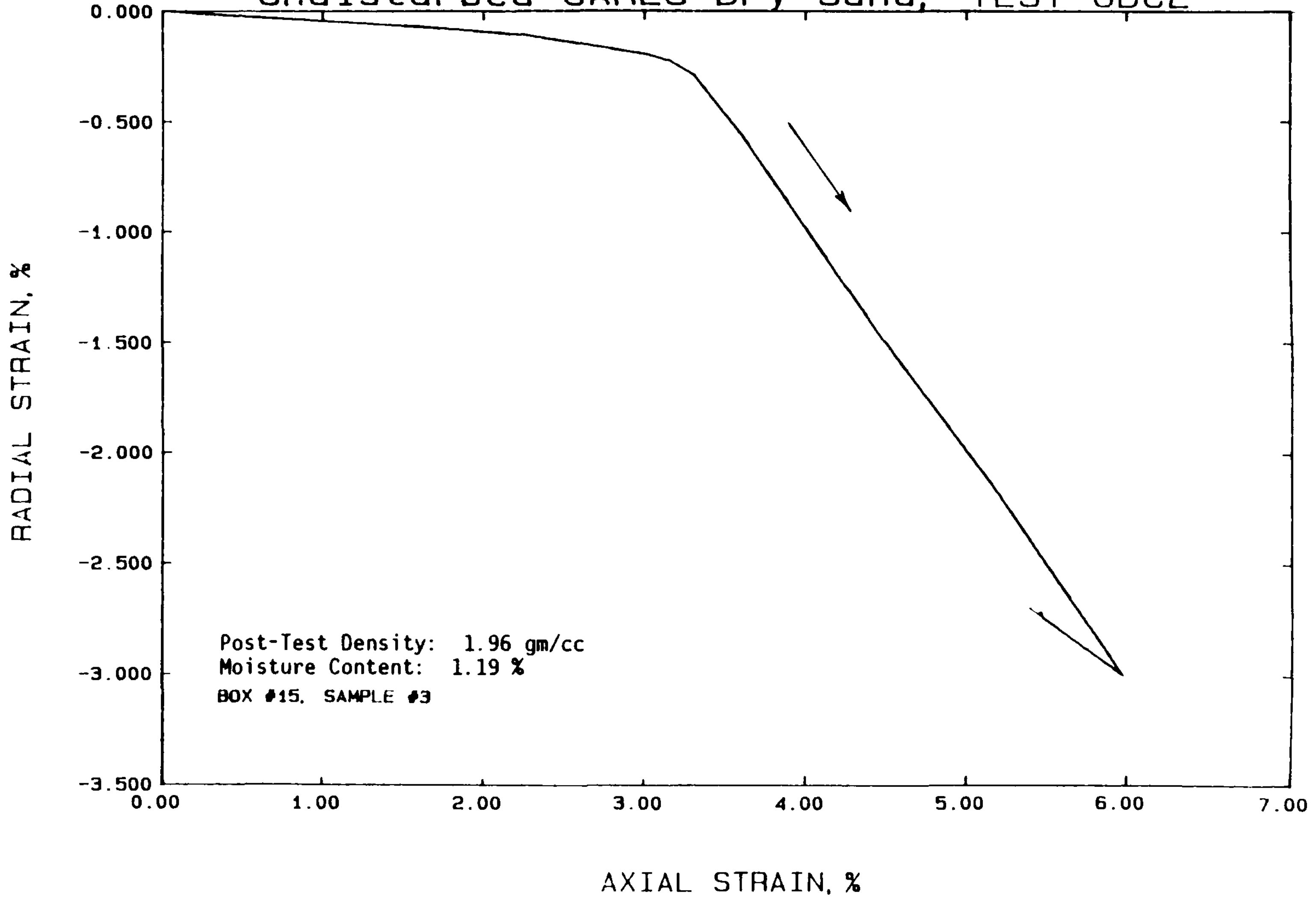
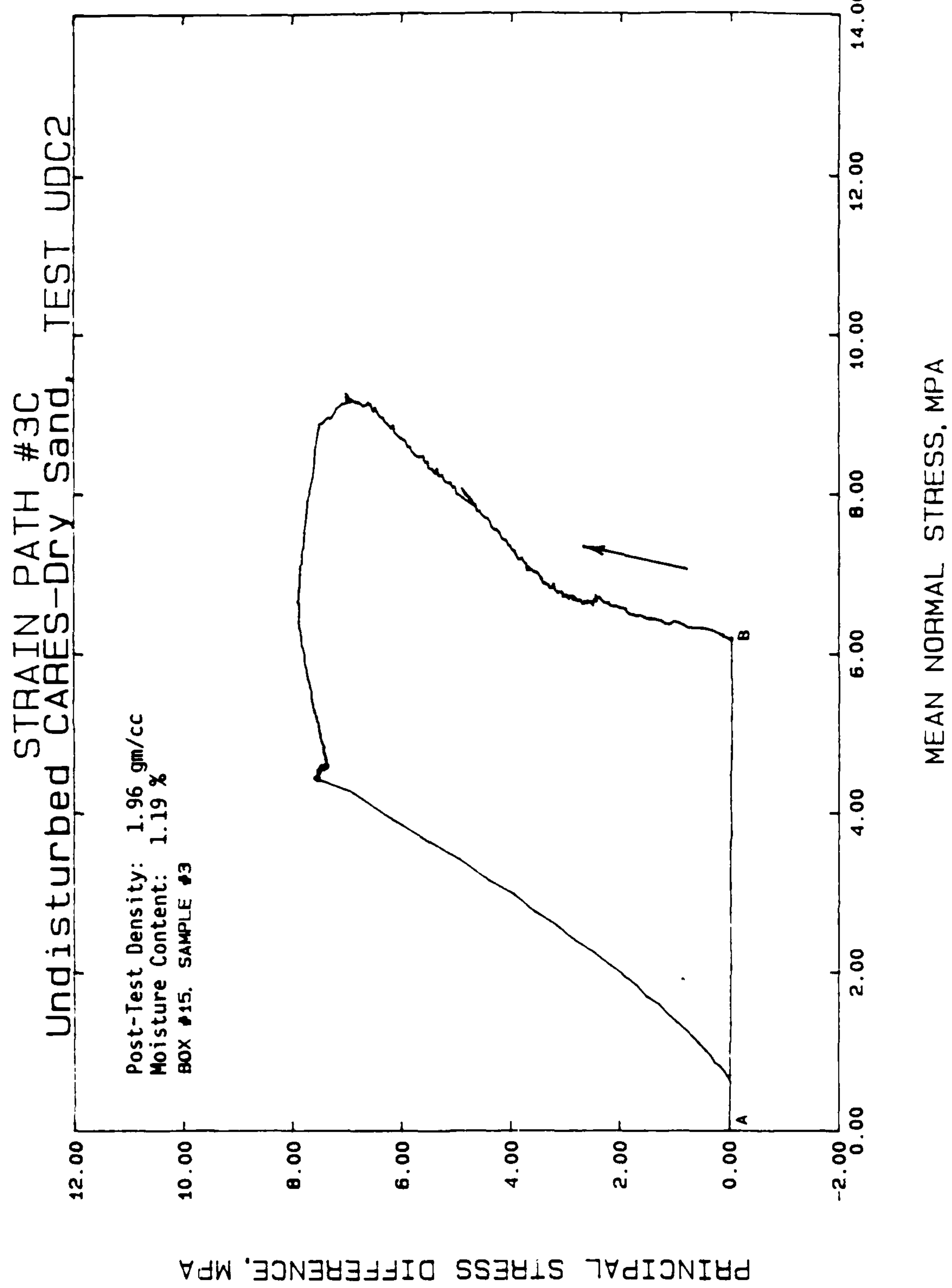
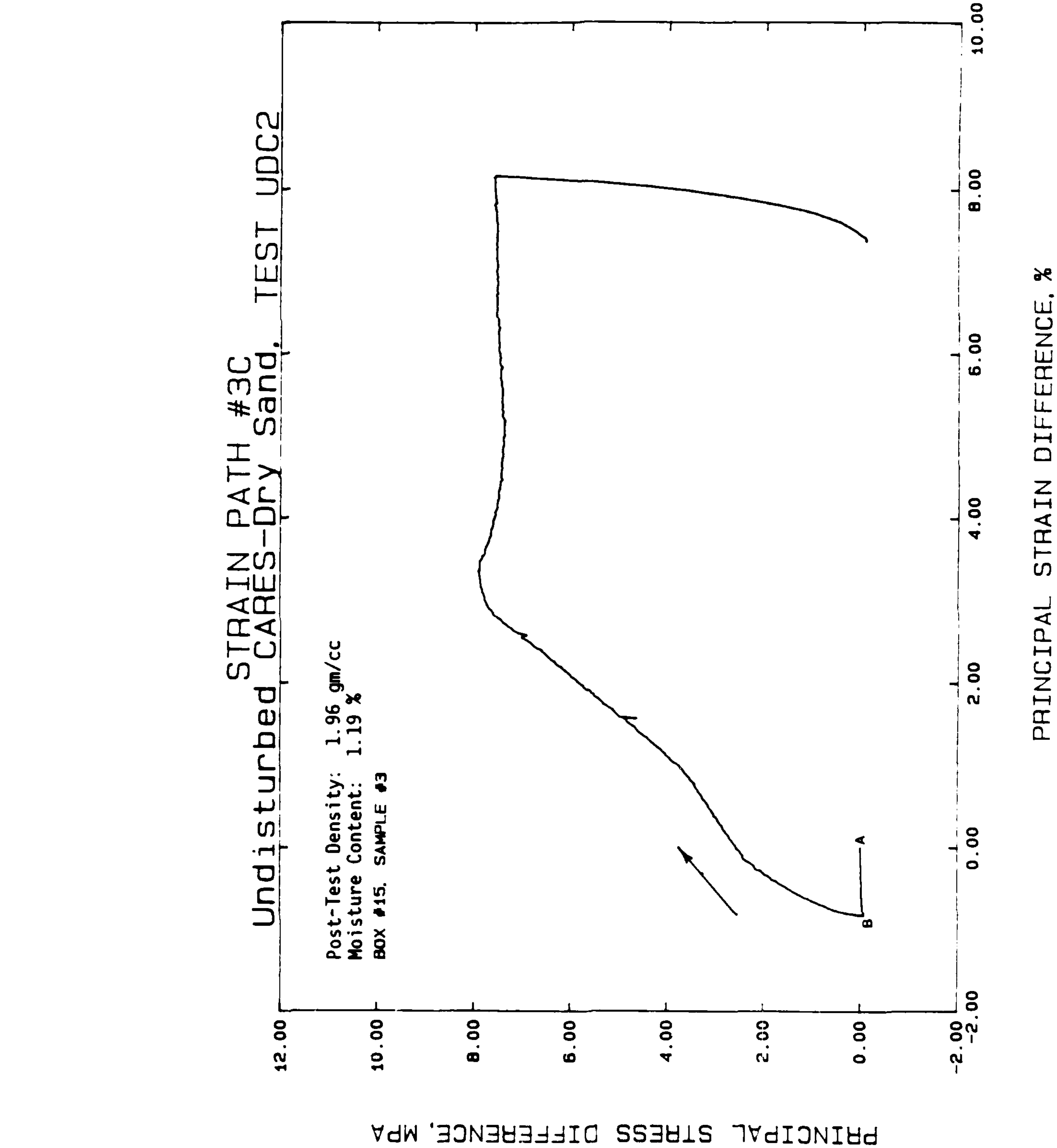


Plate 234



STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.96 gm/cc
Moisture Content: 1.19 %
BOX #15, SAMPLE #3
A
B
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA

Plate 235


STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.96 gm/cc
Moisture Content: 1.19 %
BOX #15, SAMPLE #3
A
B
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00

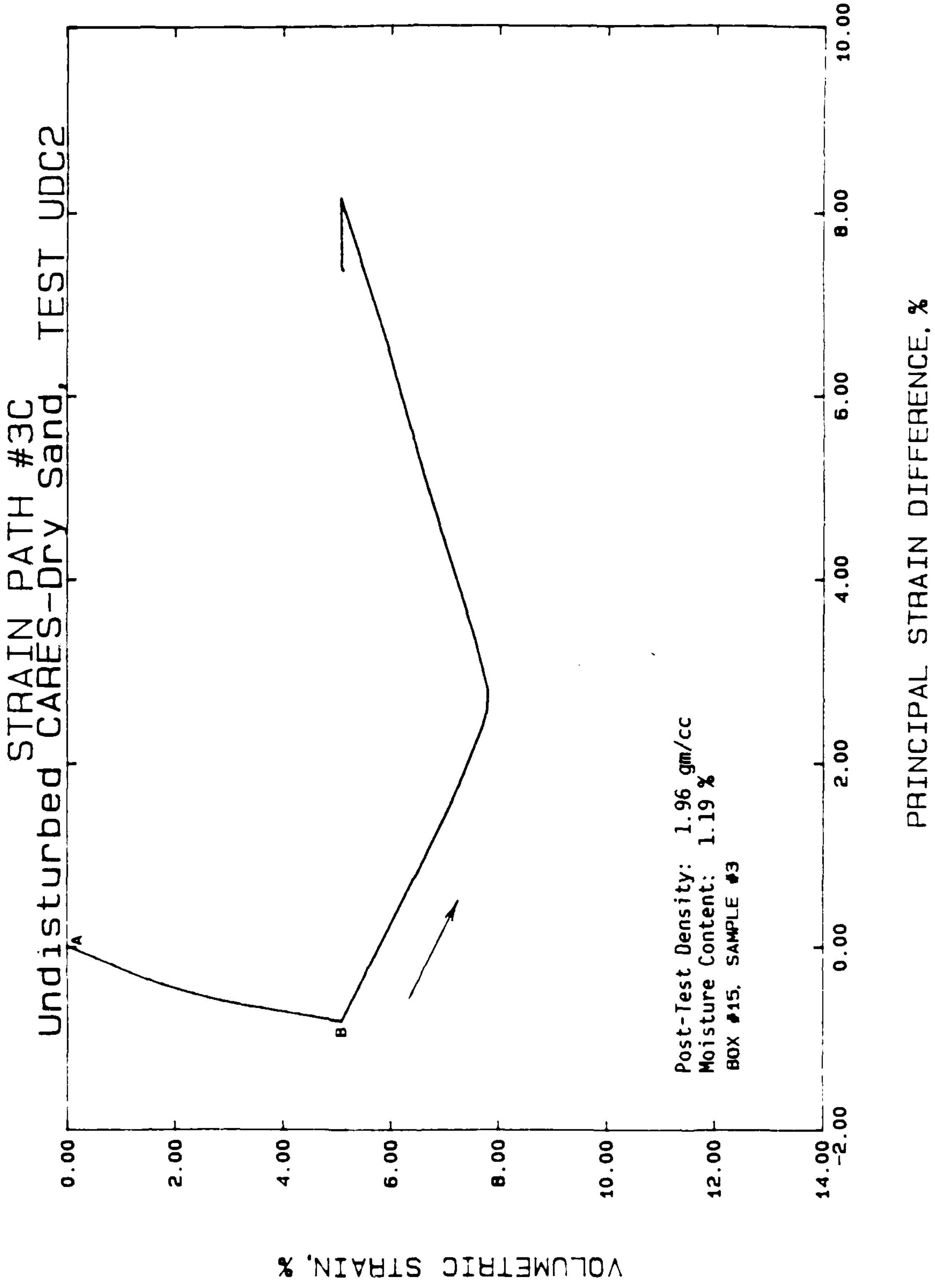

STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC2
Post-Test Density: 1.96 gm/cc
Moisture Content: 1.19 %
BOX #15, SAMPLE #3
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 237

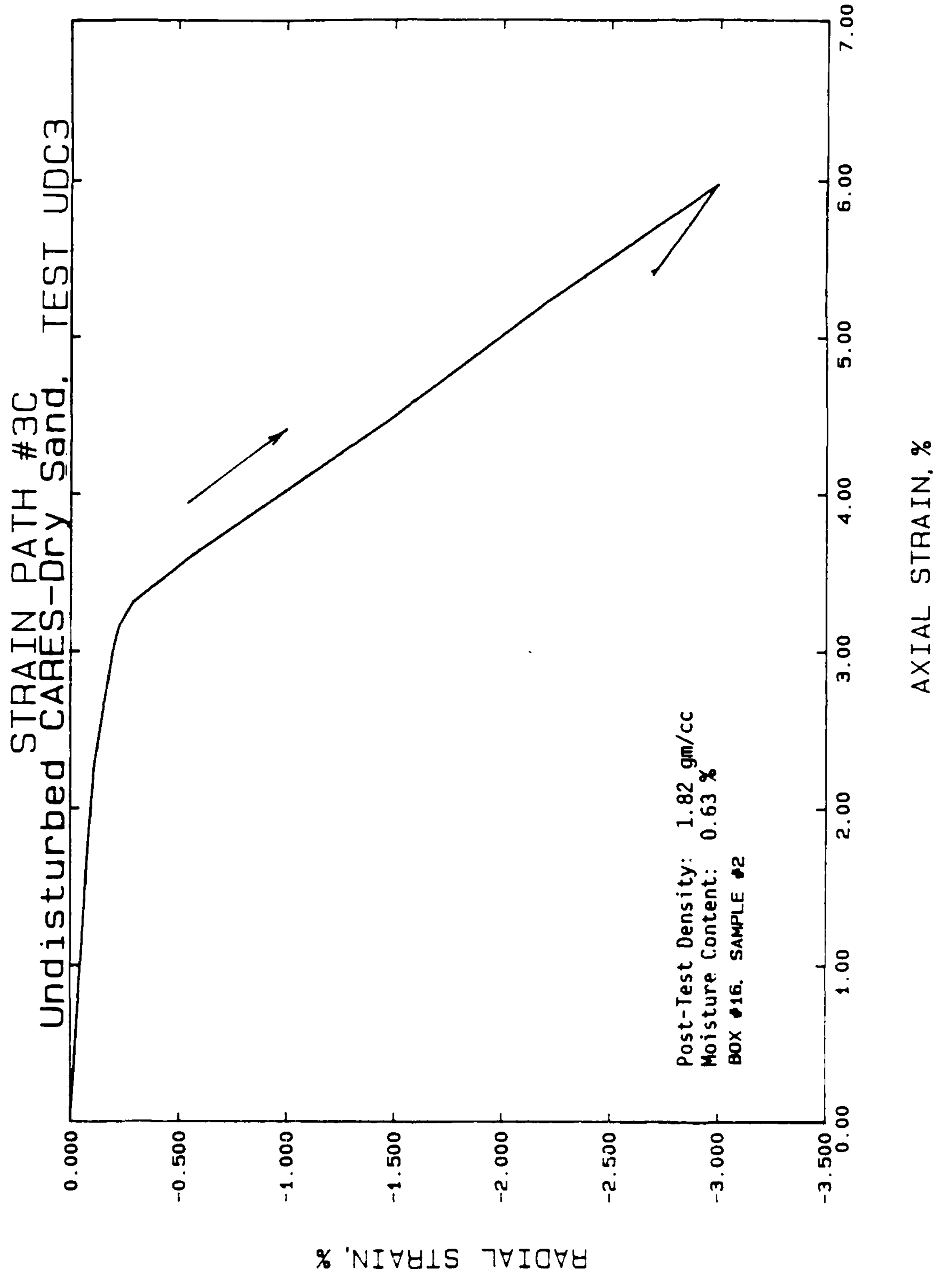
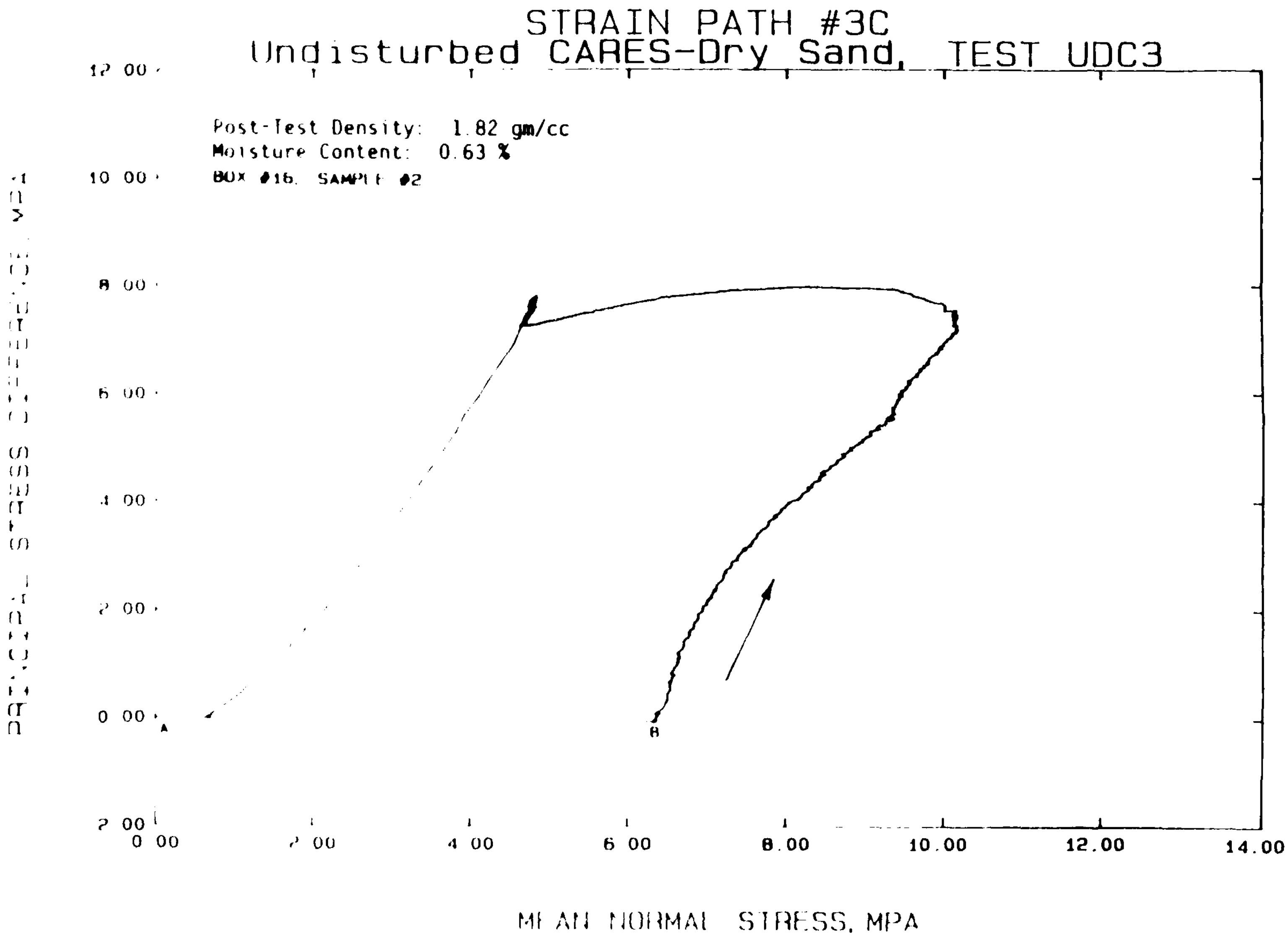
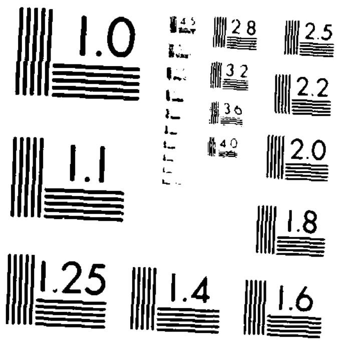

STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.82 gm/cc
Moisture Content: 0.63 %
BOX #16, SAMPLE #2
RADIAL STRAIN, %
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
-3.500
AXIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00

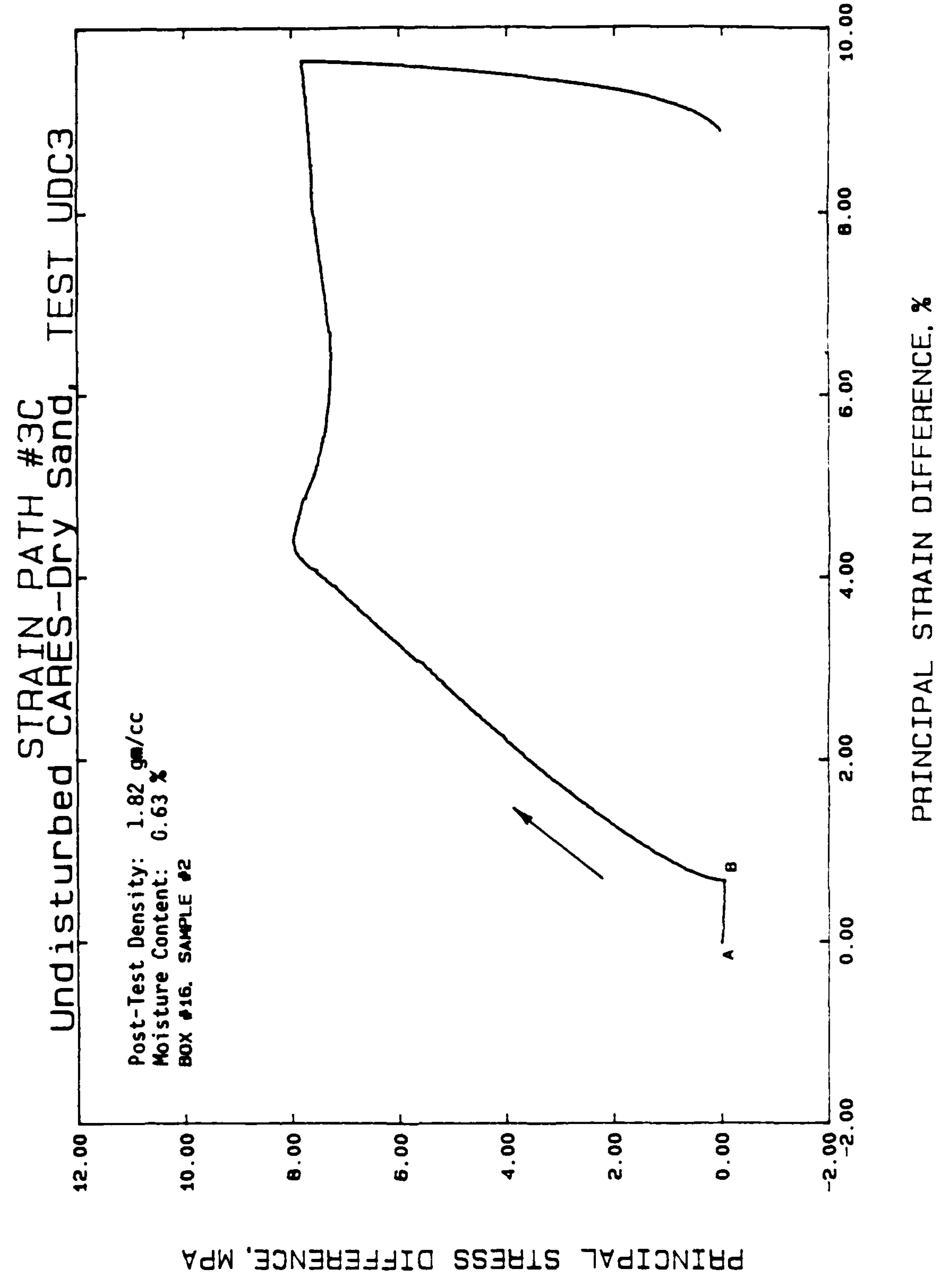
Plate 238

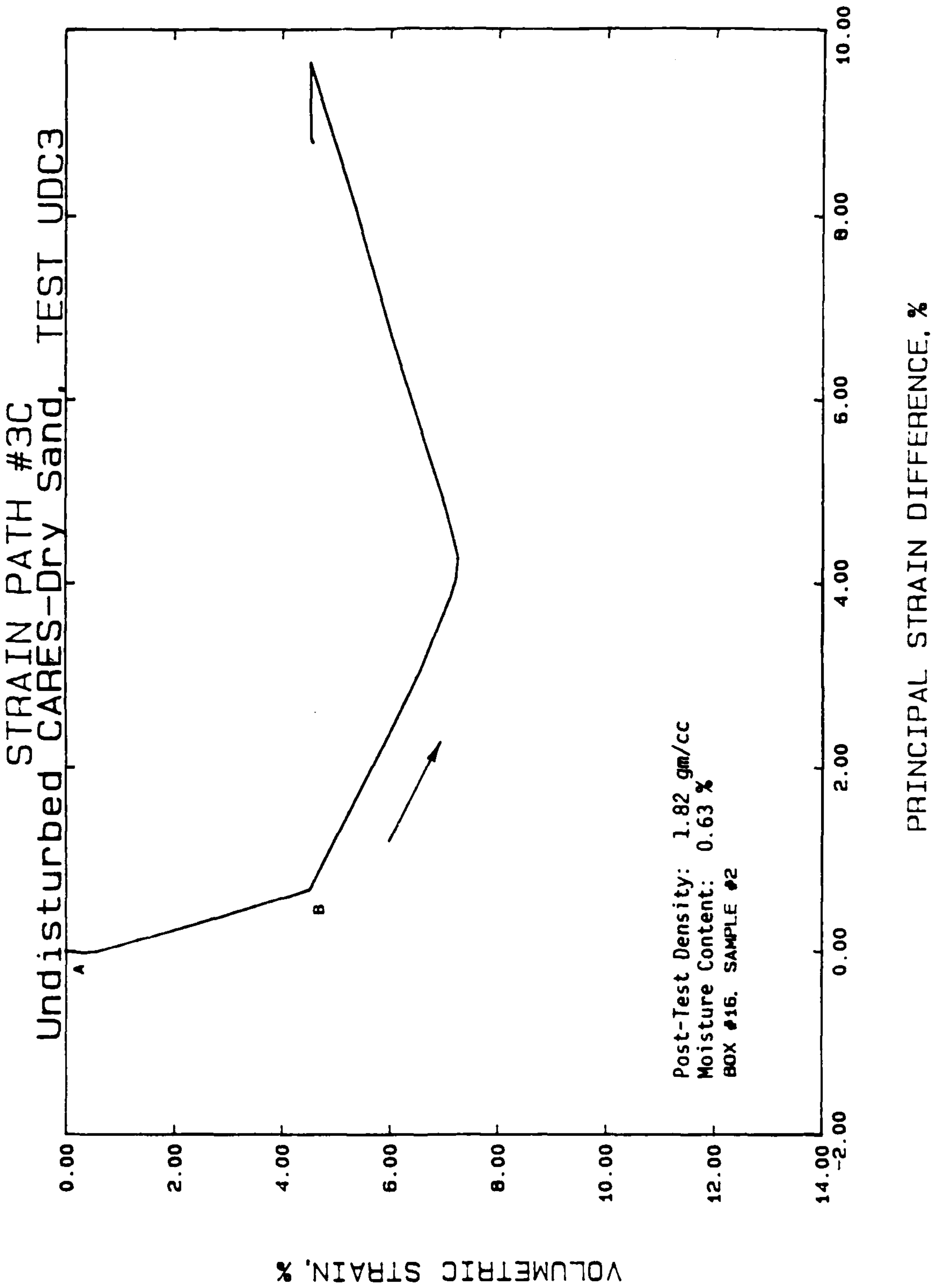

STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.82 gm/cc
Moisture Content: 0.63 %
BOX #16, SAMPLE #2
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
A
B
MEAN NORMAL STRESS, MPA

AD-A180 755 MECHANICAL PROPERTIES OF ALLUVIUM FROM NELLIS AIR FORCE 4/4
RANGE NEVADA; LUK..(U) TERRA TEK INC SALT LAKE CITY UT
J B WANGSGARD ET AL. 14 OCT 86 TR-86-76 DNA-TR-87-60
UNCLASSIFIED DNA001-83-C-0193 F/G 8/10 NL



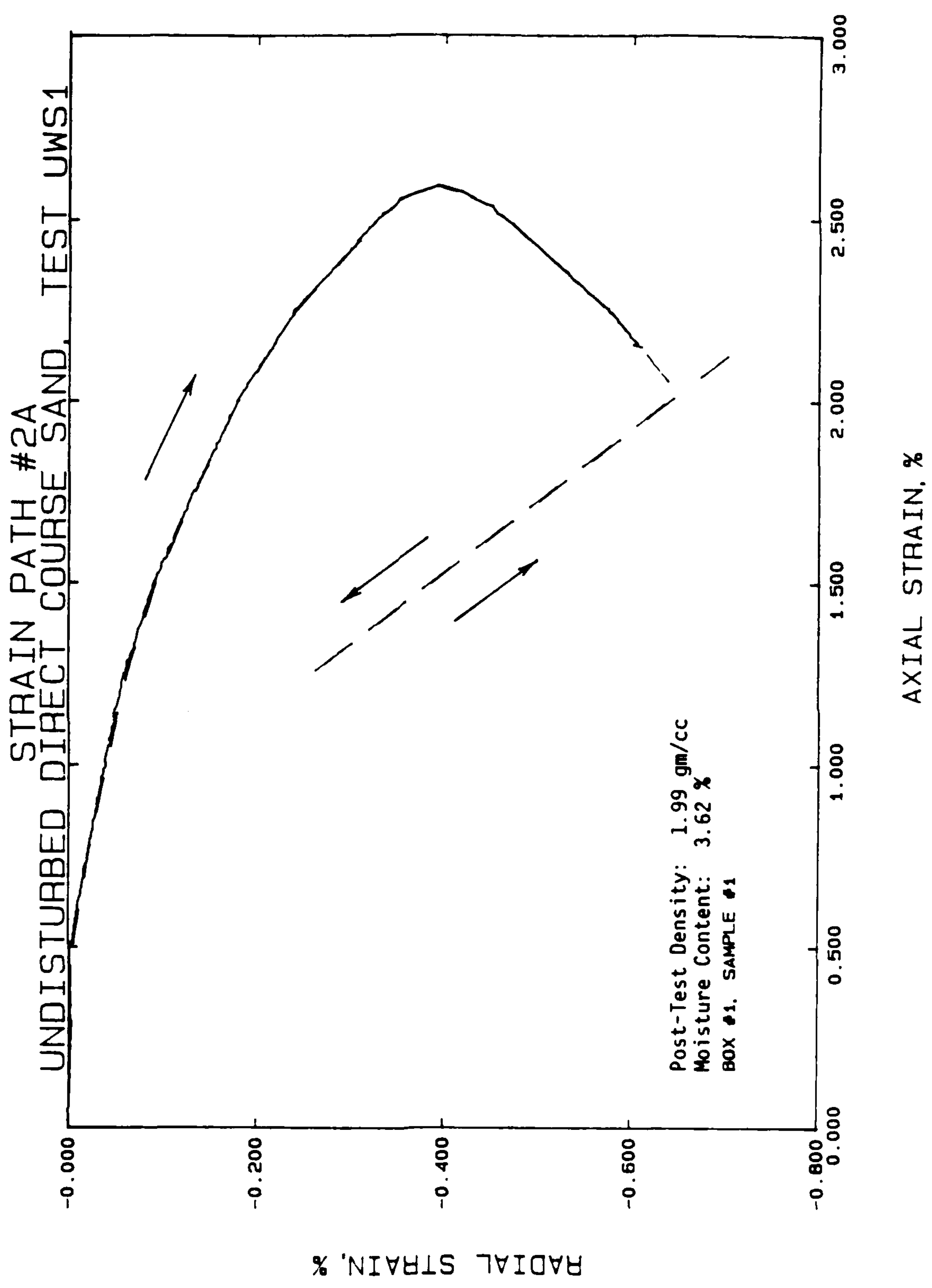
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A


STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.82 gm/cc
Moisture Content: 0.63 %
BOX #16, SAMPLE #2
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00



STRAIN PATH #3C
Undisturbed CARES-Dry Sand, TEST UDC3
Post-Test Density: 1.82 gm/cc
Moisture Content: 0.63 %
BOX #16, SAMPLE #2
A
B
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00

Plate 241


STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.99 gm/cc
Moisture Content: 3.62 %
BOX #1, SAMPLE #1
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

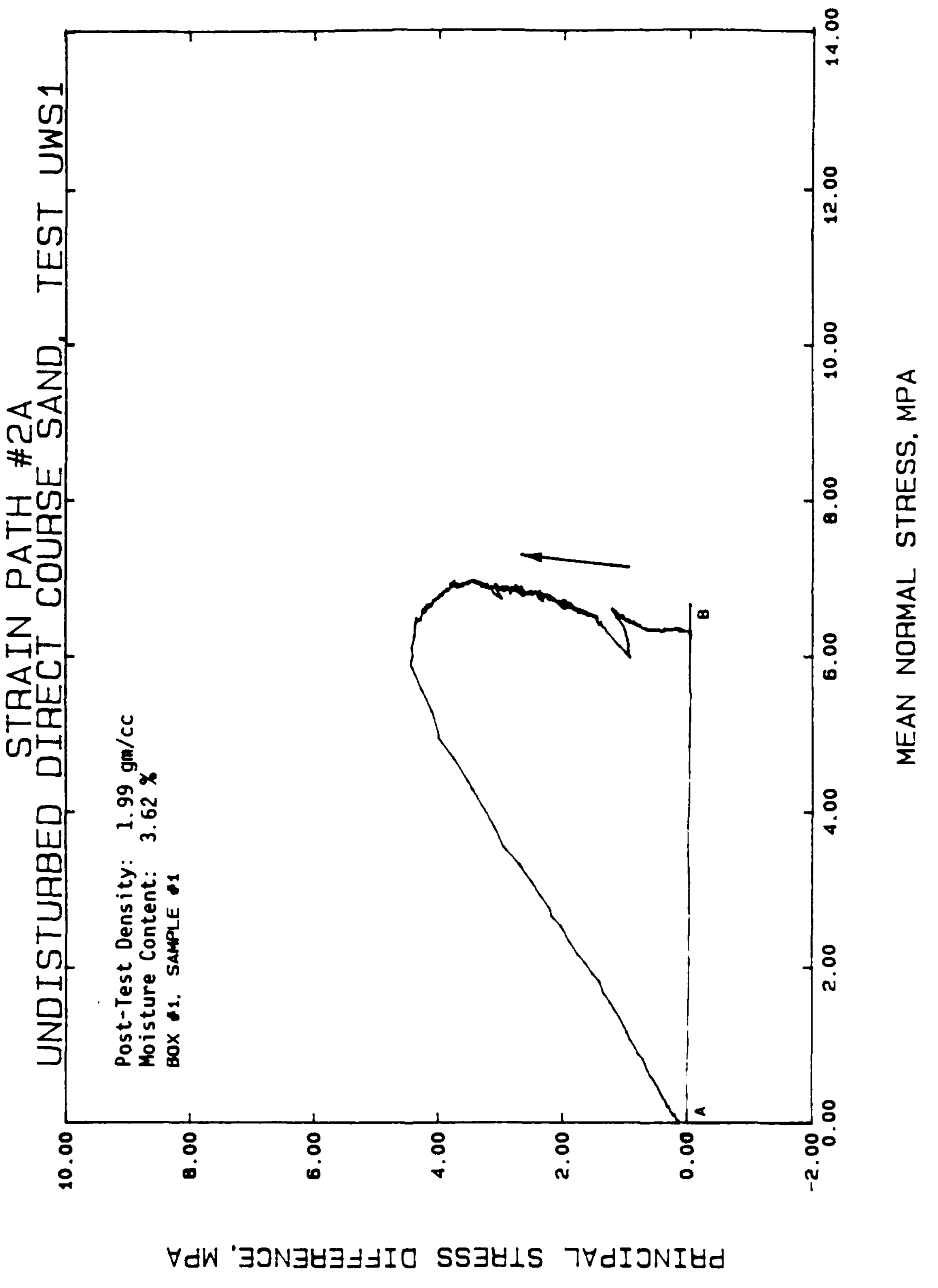

STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.99 gm/cc
Moisture Content: 3.62 %
BOX #1, SAMPLE #1
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 243

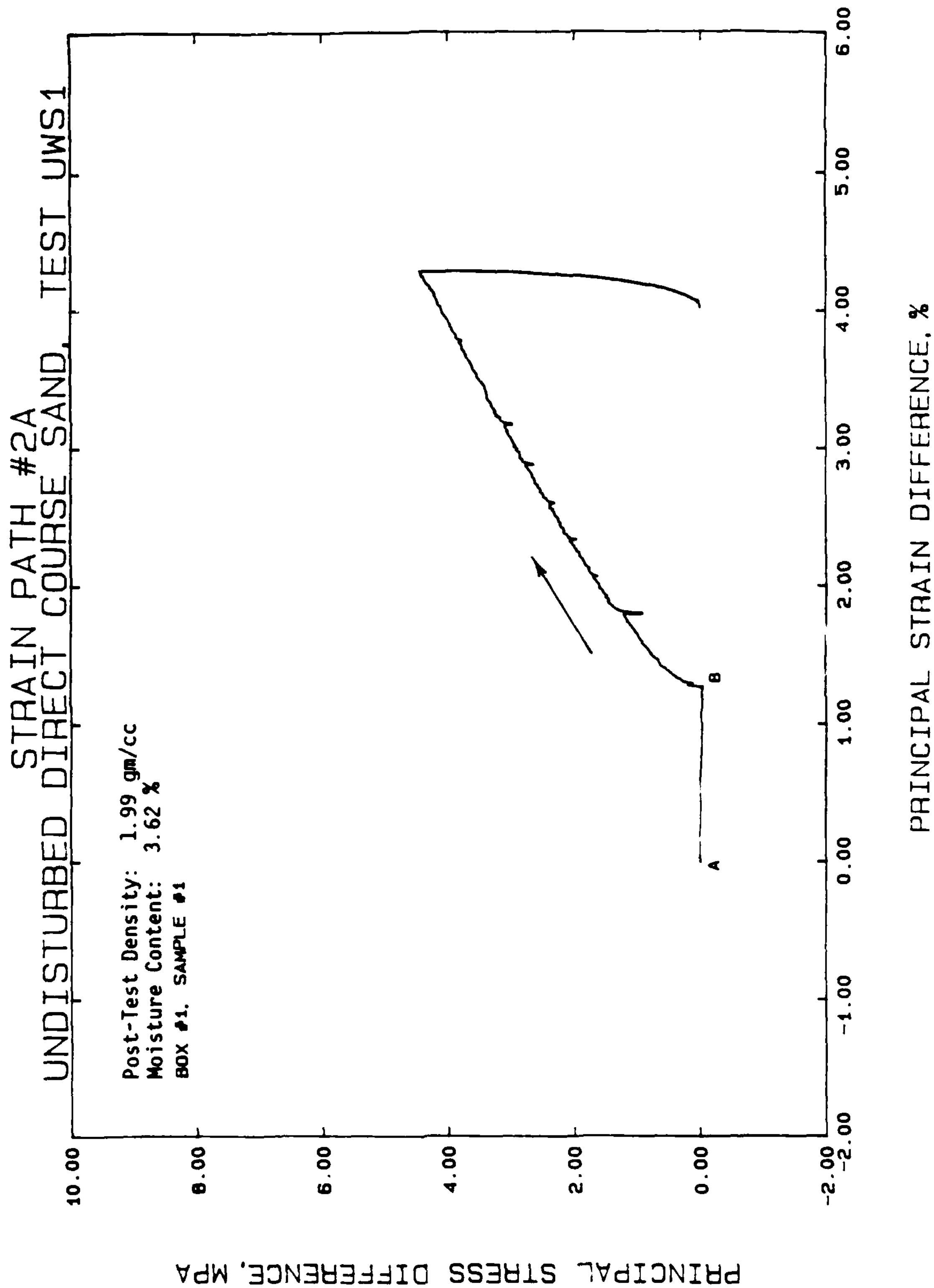
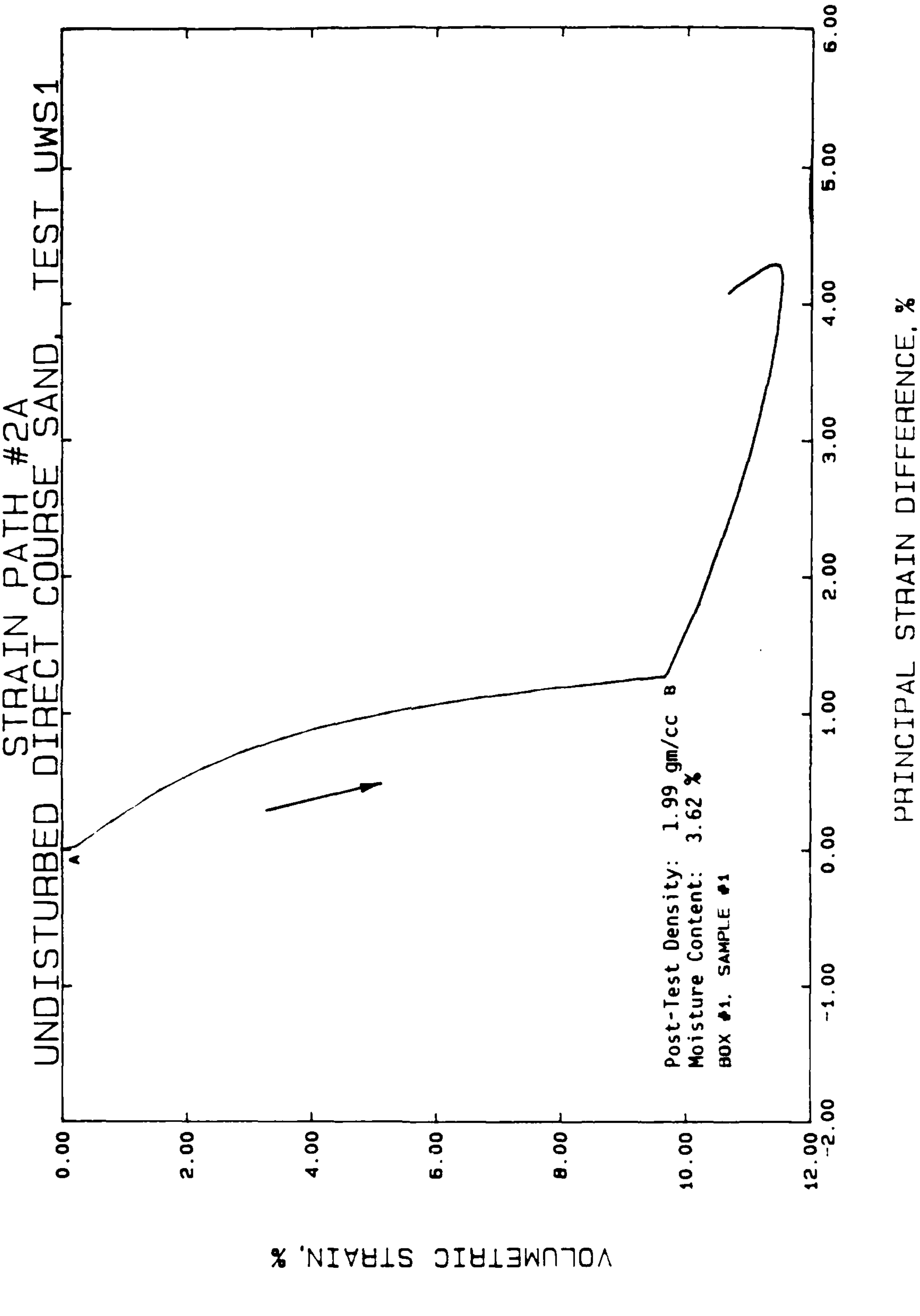

STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.99 gm/cc
Moisture Content: 3.62 %
BOX #1, SAMPLE #1
A
B
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00

Plate 244



STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.99 gm/cc
Moisture Content: 3.62 %
BOX #1, SAMPLE #1
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00

Plate 245

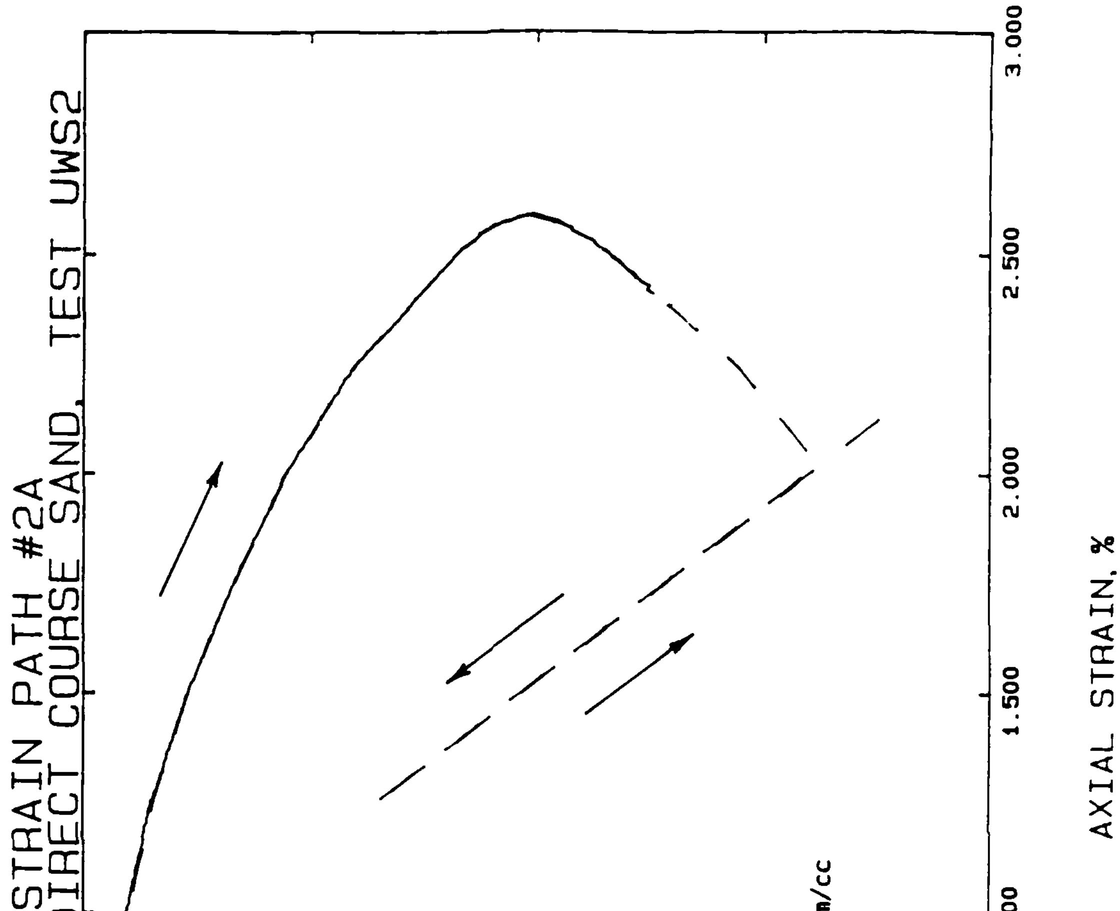
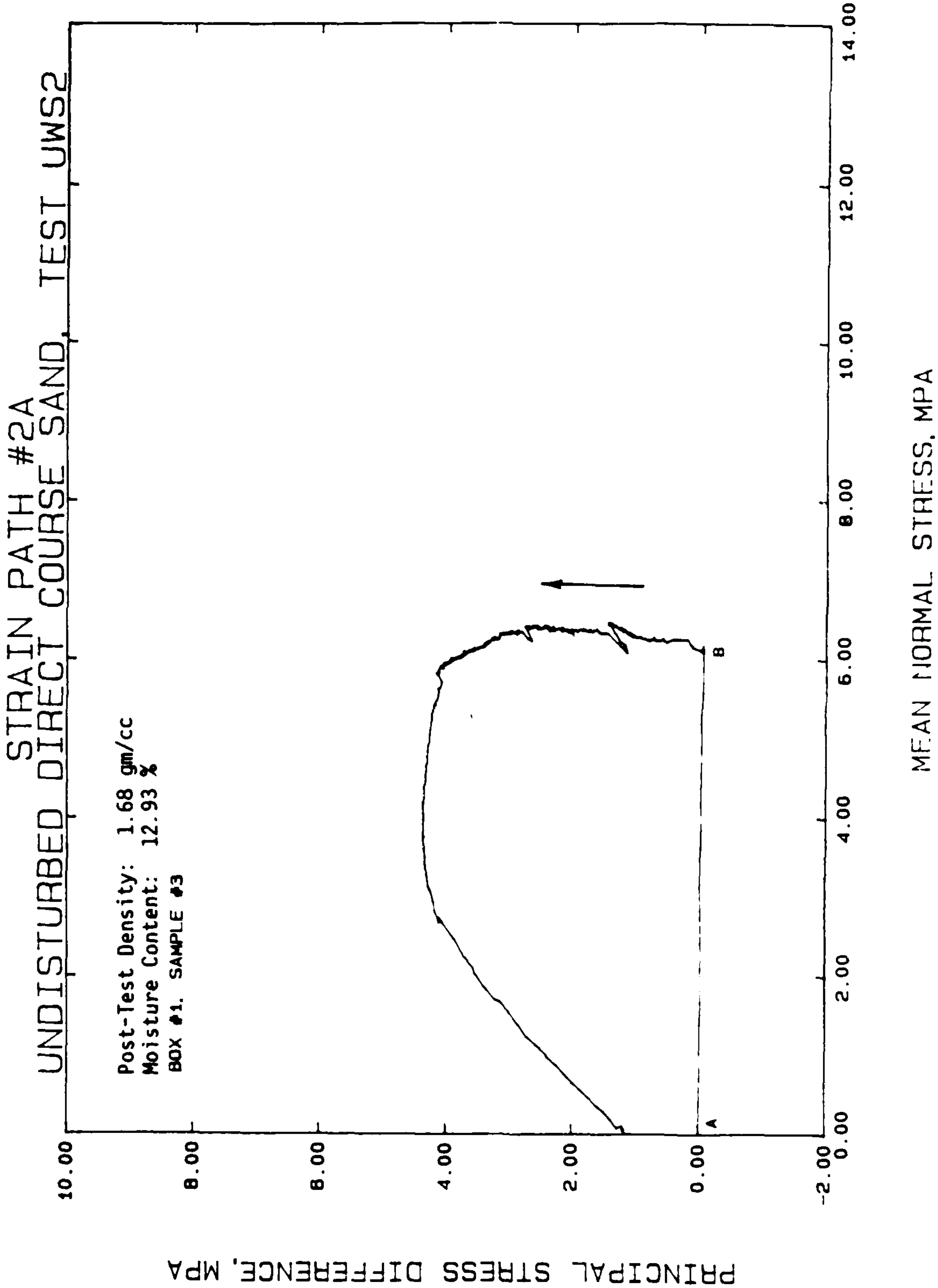

STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS2
Post-Test Density: 1.68 gm/cc
Moisture Content: 12.93 %
BOX #1. SAMPLE #3
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.500
1.000
1.500
2.000
2.500
3.000
-0.000
-0.200
-0.400
-0.600
-0.800

Plate 246



STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS2
Post-Test Density: 1.68 gm/cc
Moisture Content: 12.93 %
BOX #1. SAMPLE #3
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 247

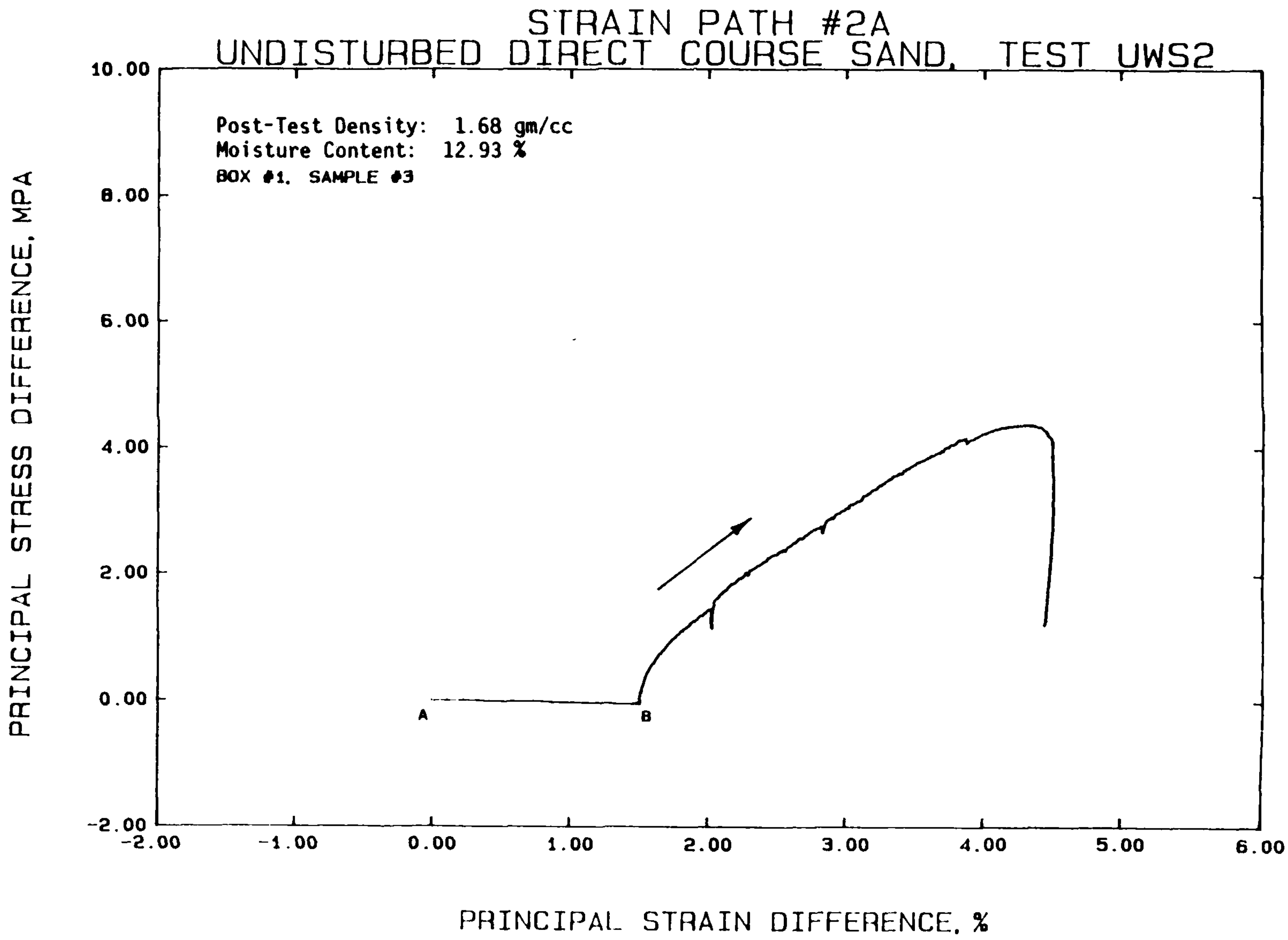
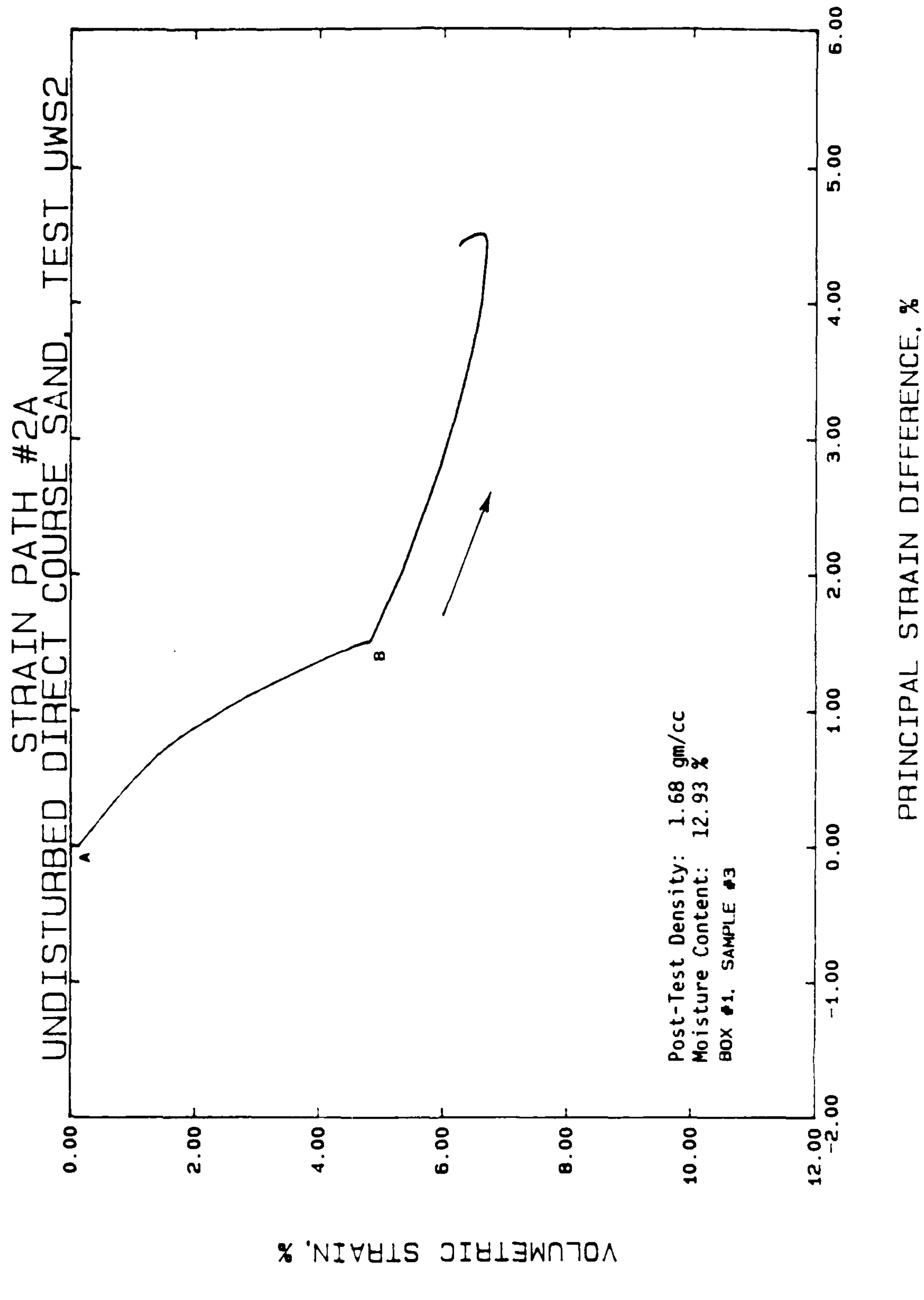
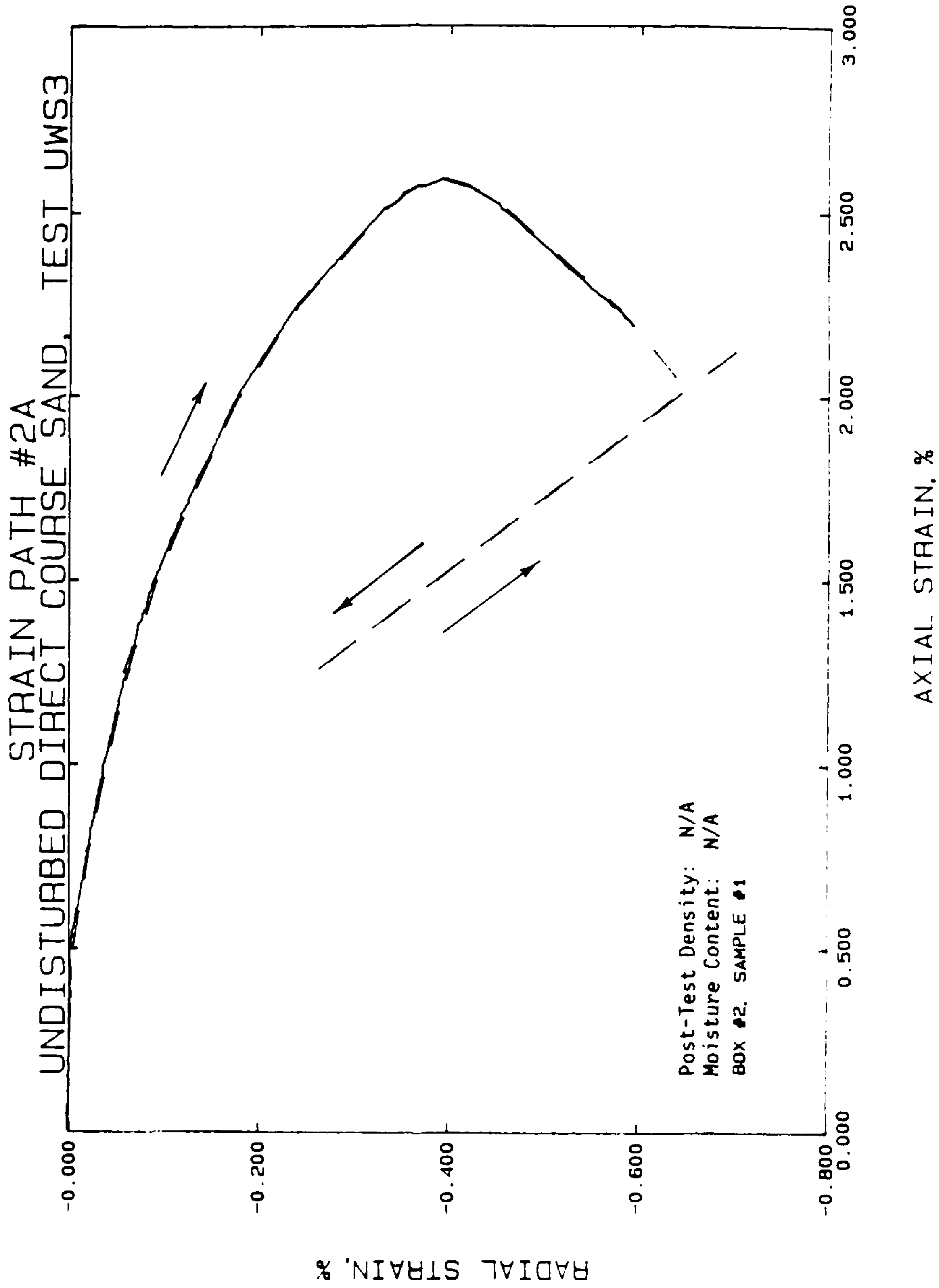
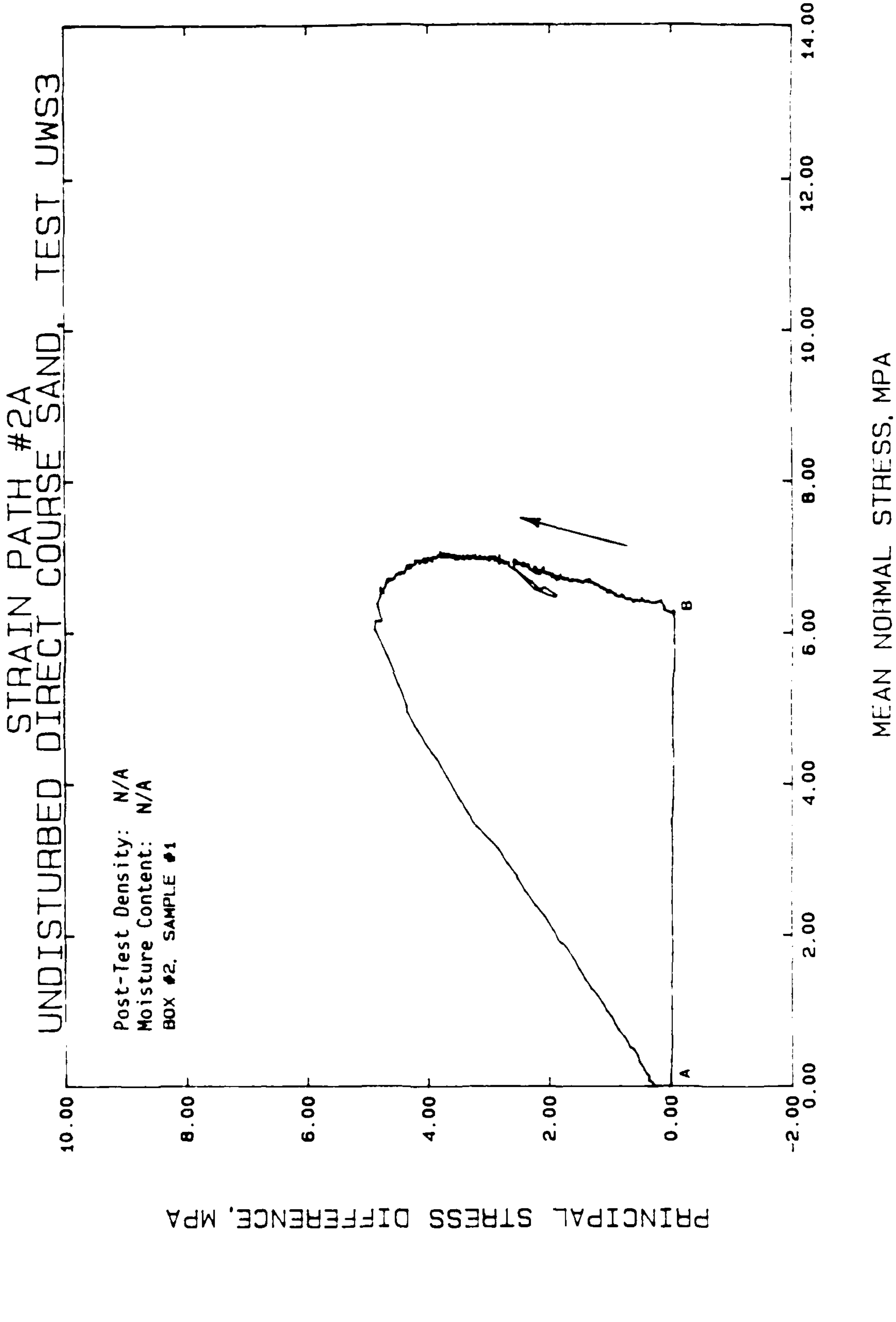

STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS2
Post-Test Density: 1.68 gm/cc
Moisture Content: 12.93 %
BOX #1, SAMPLE #3
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %

Plate 248


STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS2
Post-Test Density: 1.68 gm/cc
Moisture Content: 12.93 %
BOX #1, SAMPLE #3
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00


STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS3
Post-Test Density: N/A
Moisture Content: N/A
BOX #2, SAMPLE #1
RADIAL STRAIN, %
AXIAL STRAIN, %
-0.000
-0.200
-0.400
-0.600
-0.800
0.000
0.500
1.000
1.500
2.000
2.500
3.000



STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS3
Post-Test Density: N/A
Moisture Content: N/A
BOX #2, SAMPLE #1
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 151

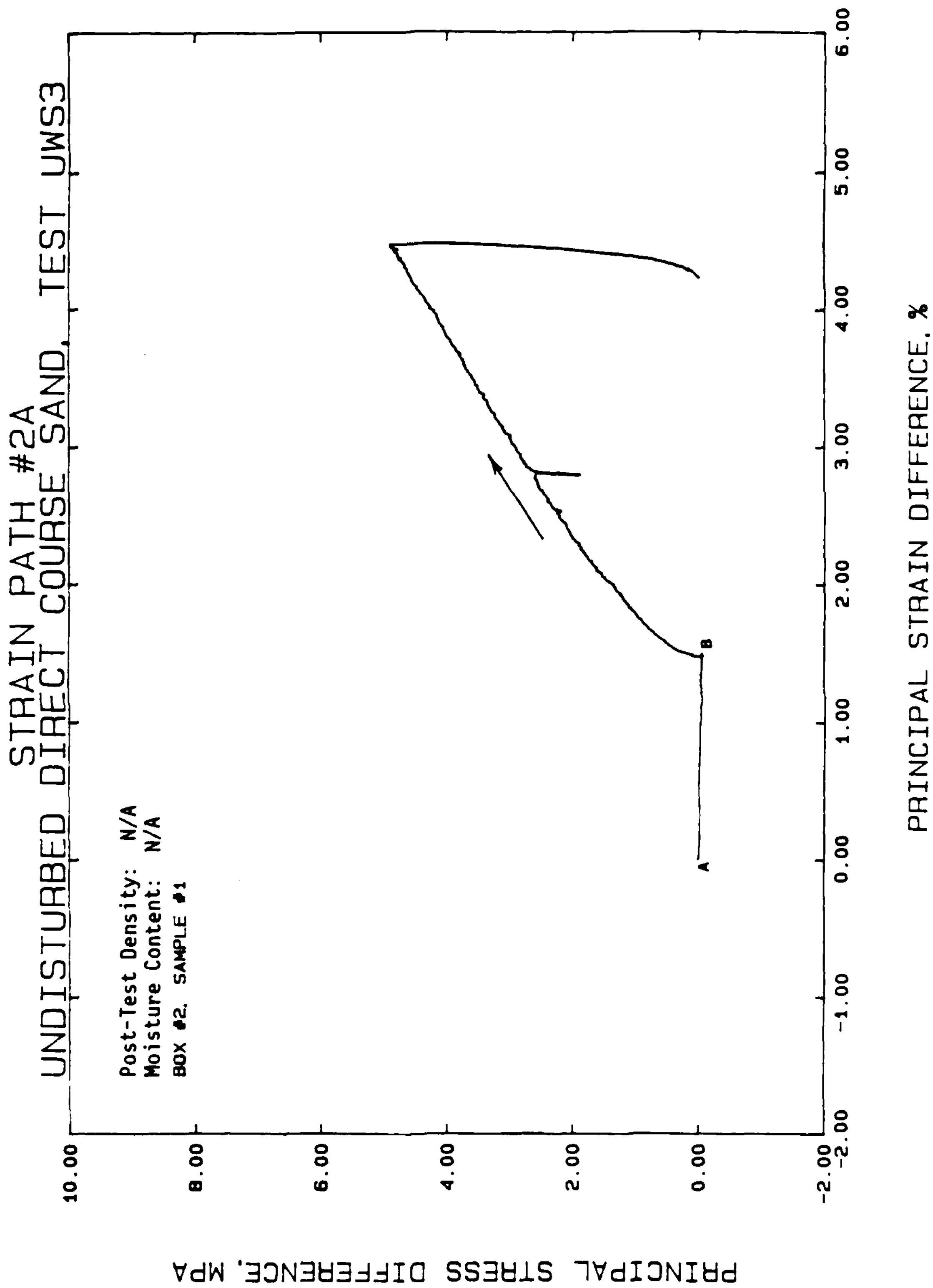

STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS3
Post-Test Density: N/A
Moisture Content: N/A
BOX #2, SAMPLE #1
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00

Plate 252

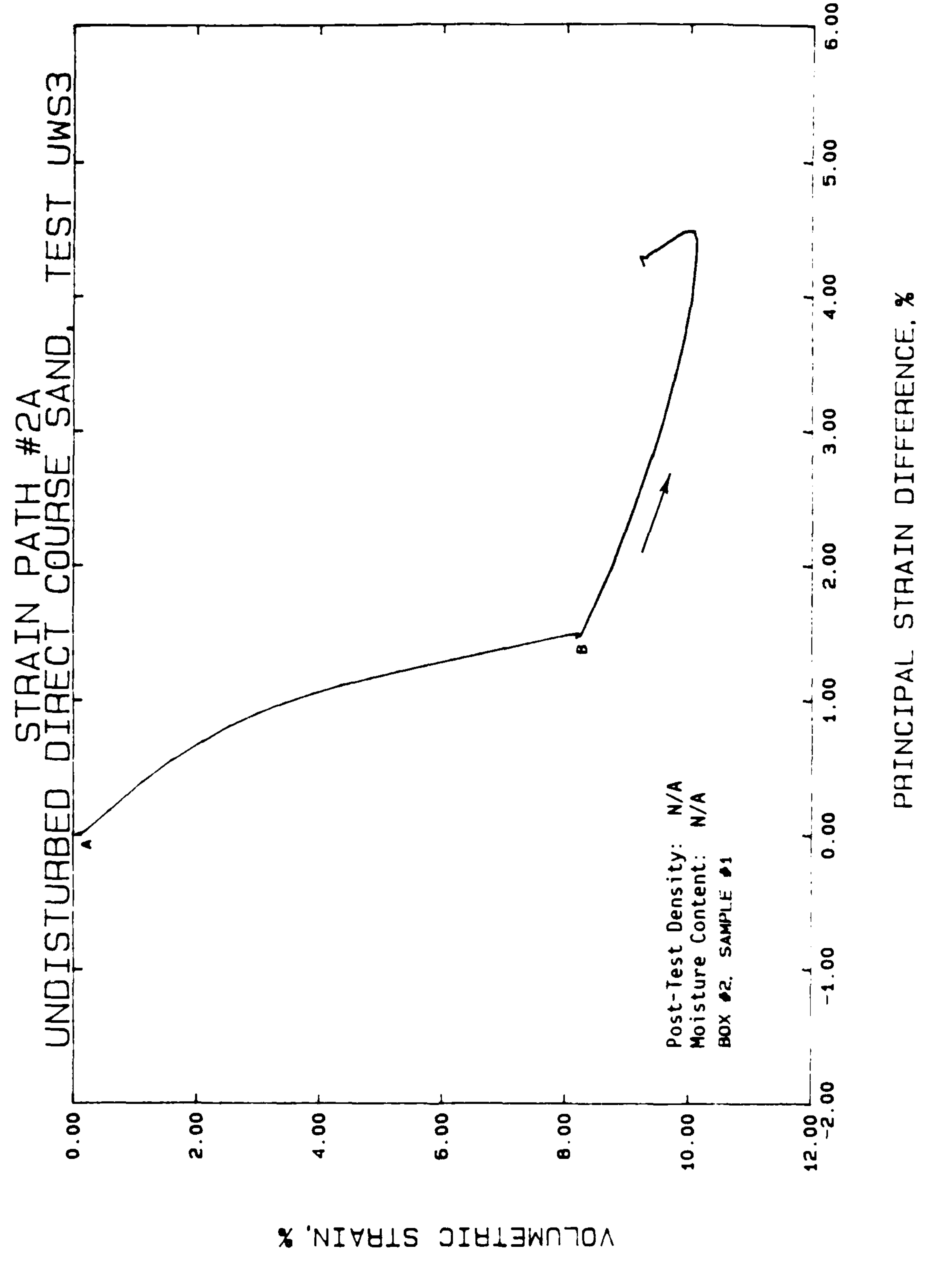

STRAIN PATH #2A
UNDISTURBED DIRECT COURSE SAND, TEST UWS3
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
A
B
Post-Test Density: N/A
Moisture Content: N/A
BOX #2, SAMPLE #1

Plate 253

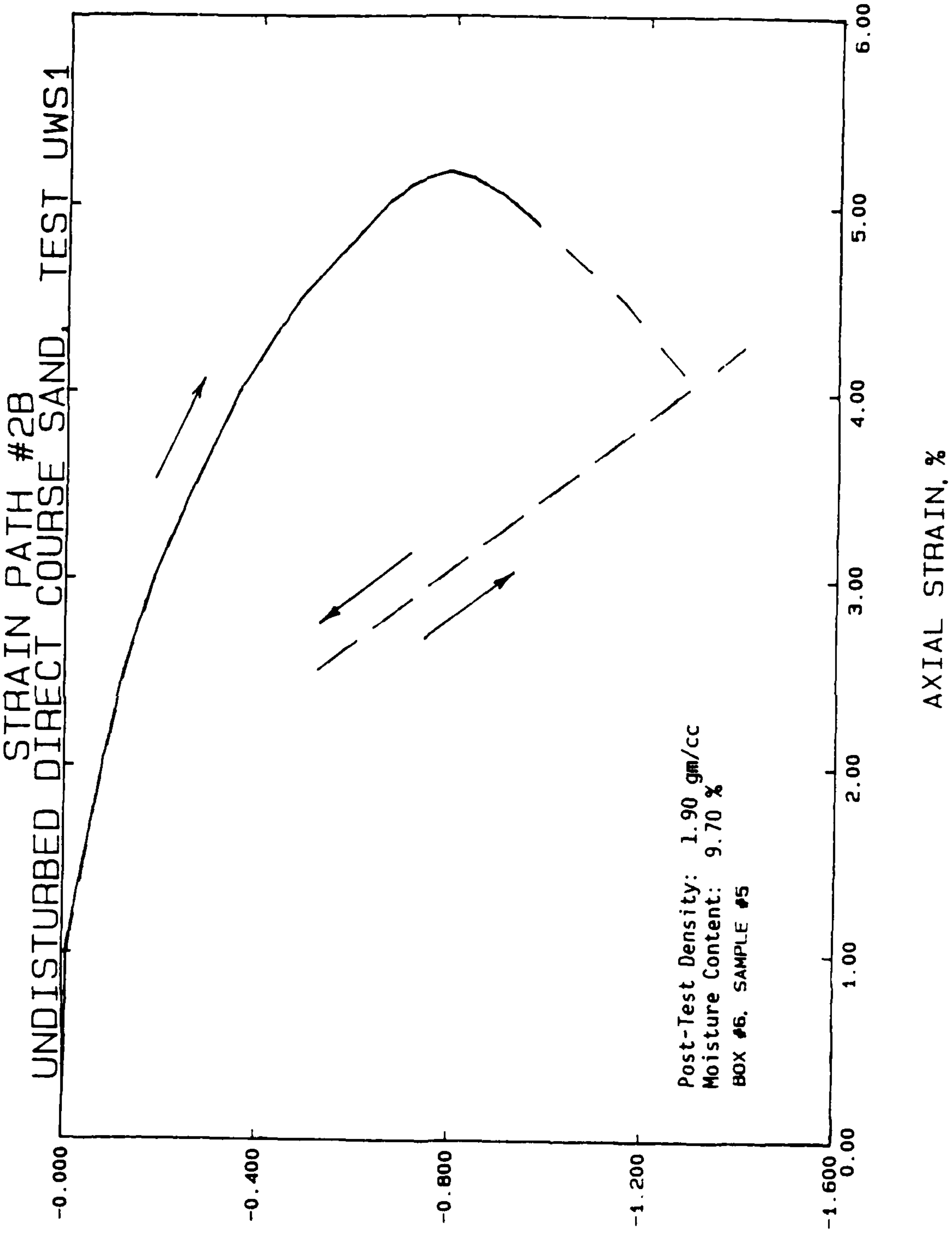
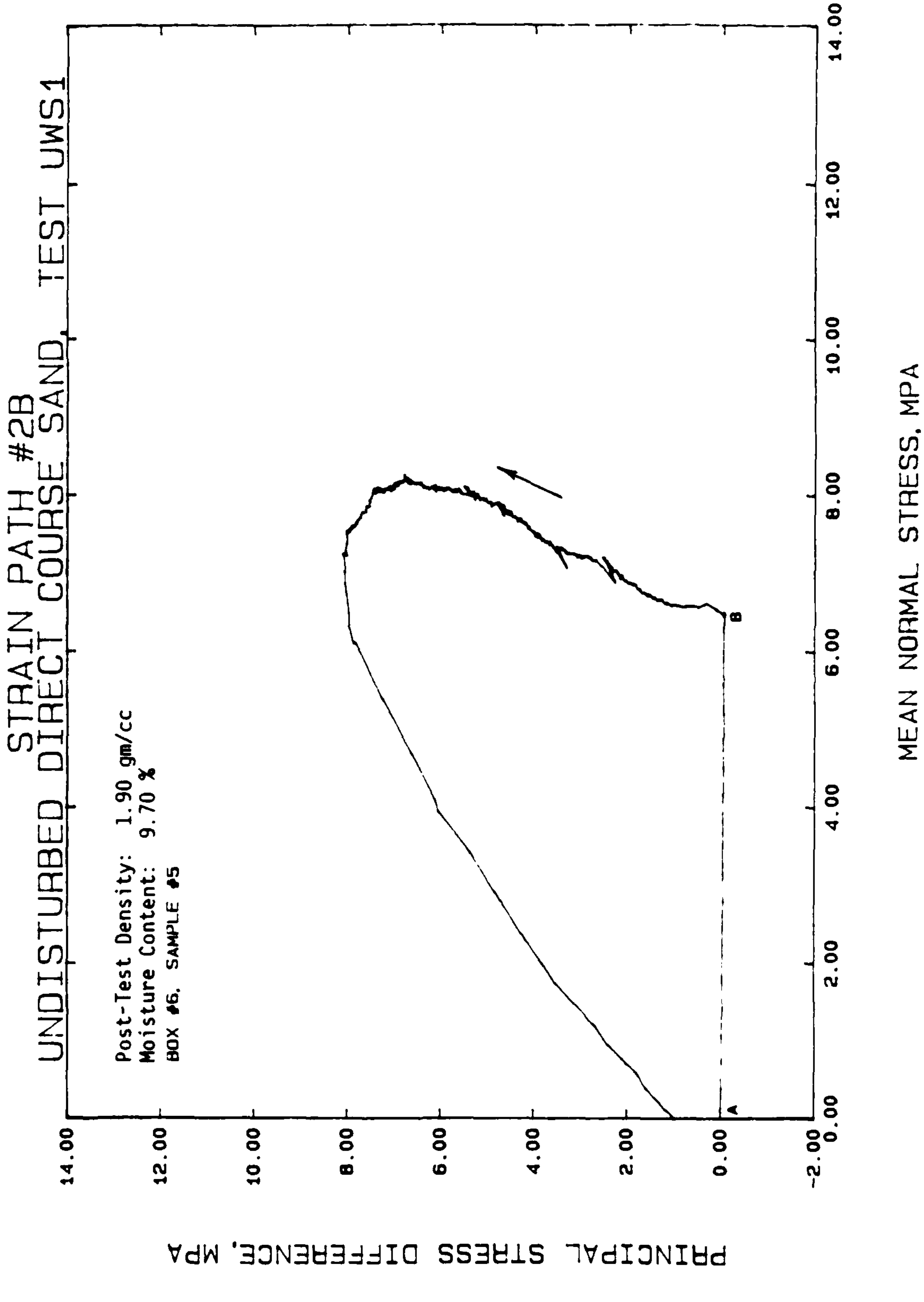
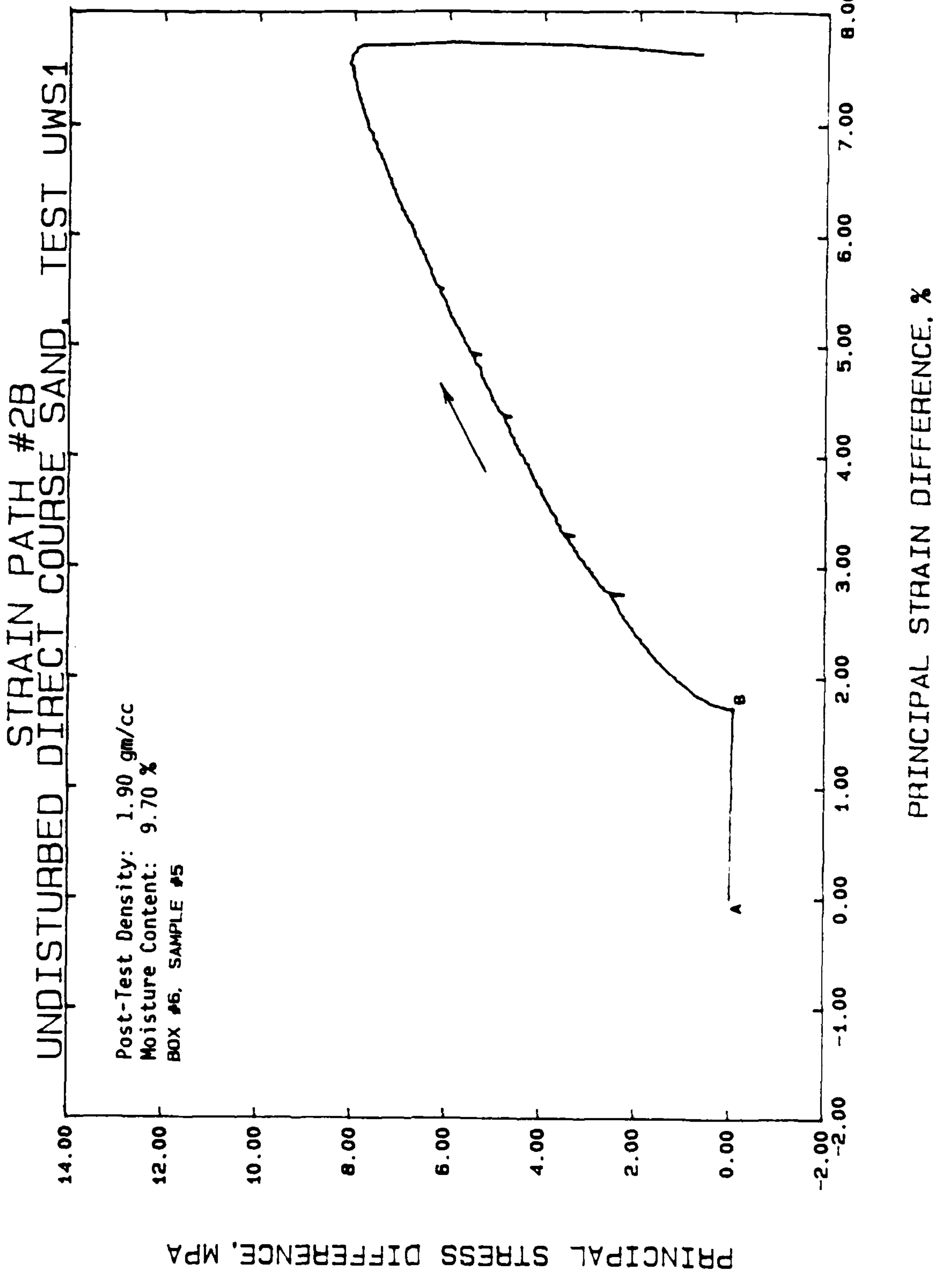

STRAIN PATH #2B
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.90 gm/cc
Moisture Content: 9.70 %
BOX #6, SAMPLE #5
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
-0.000
-0.400
-0.800
-1.200
-1.600

Plate 254



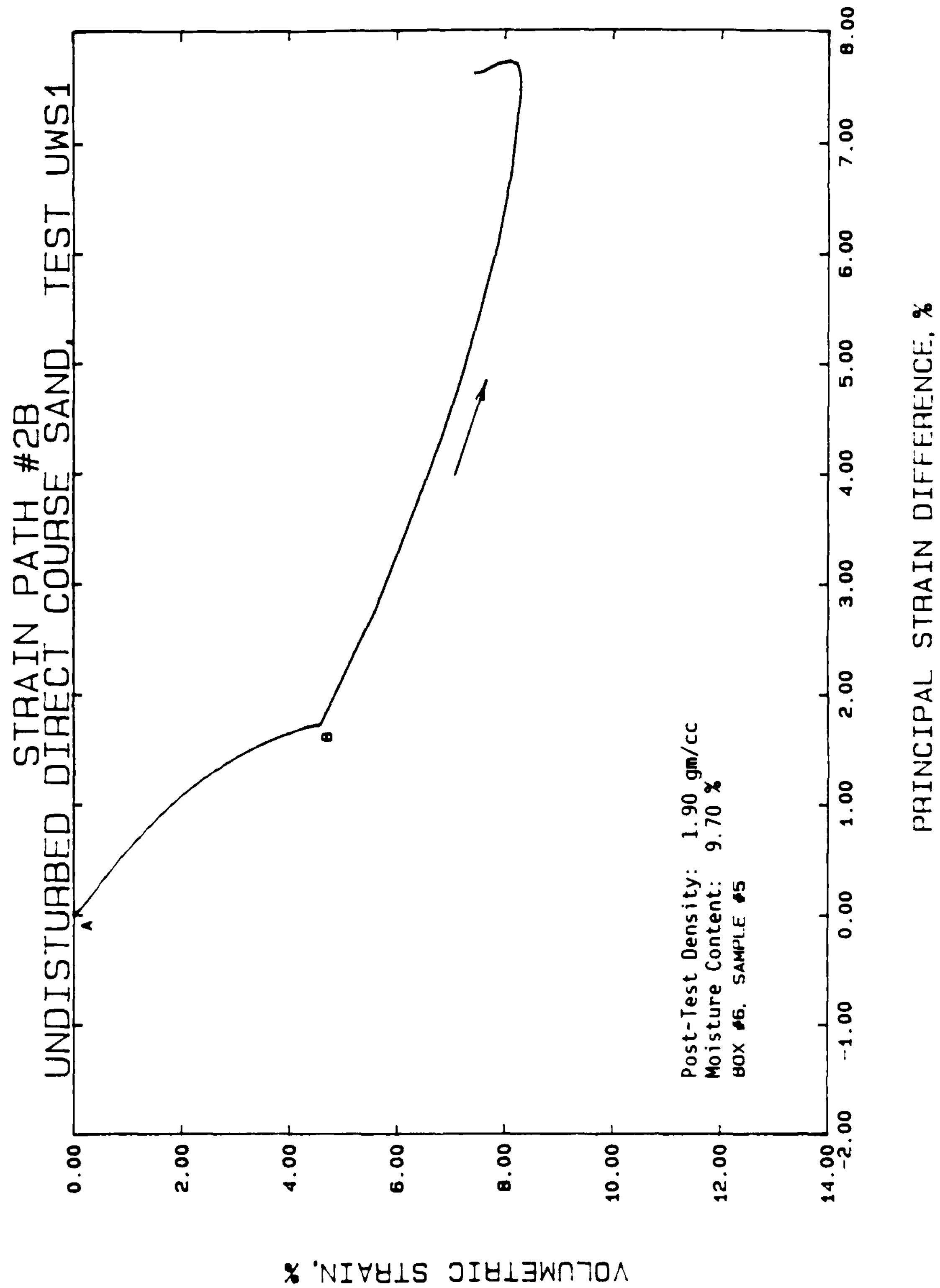
STRAIN PATH #2B
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.90 gm/cc
Moisture Content: 9.70 %
BOX #6, SAMPLE #5
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00

Plate 255

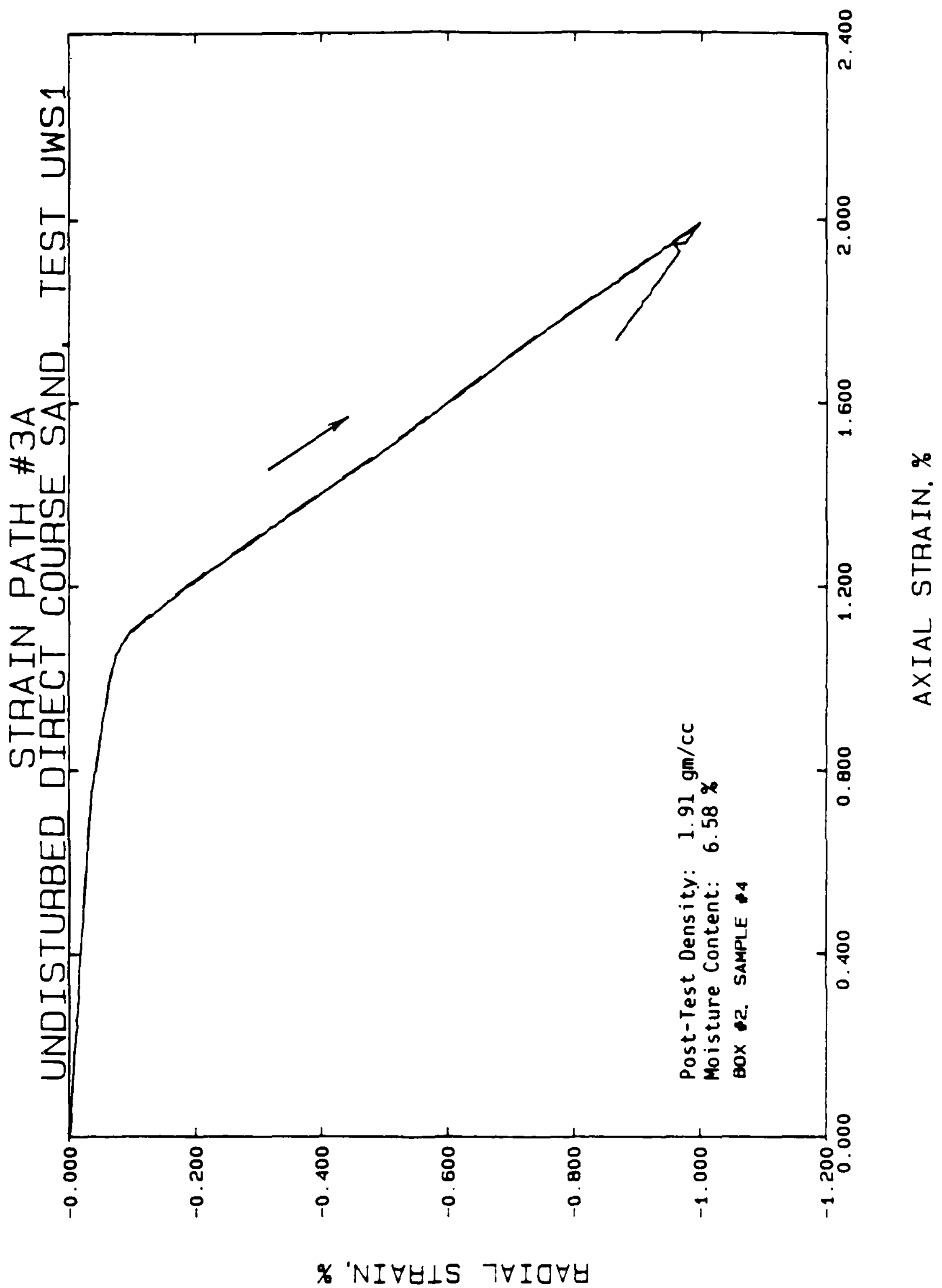


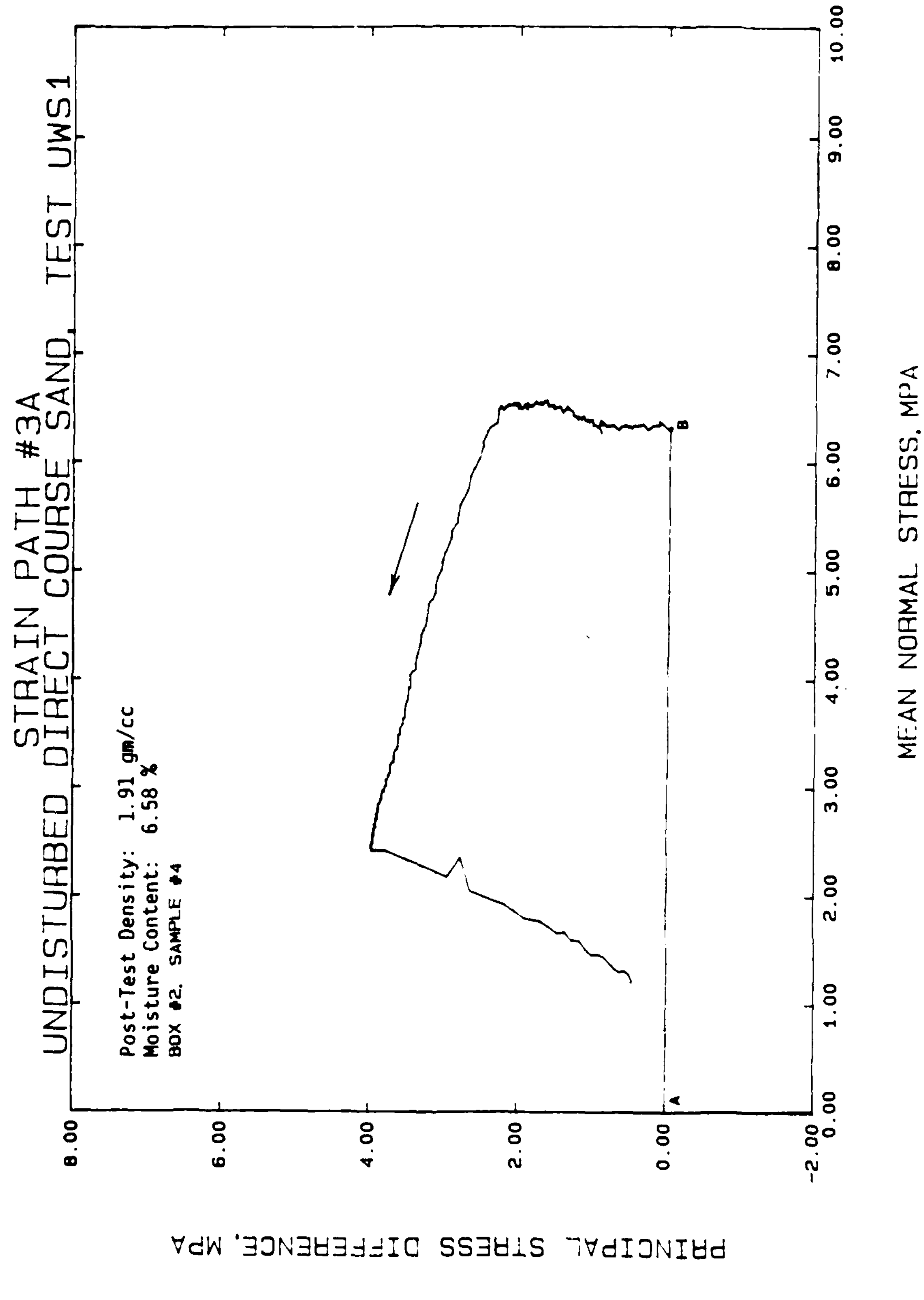
STRAIN PATH #2B
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.90 gm/cc
Moisture Content: 9.70 %
BOX #6, SAMPLE #5
A
B
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
10.00
12.00
14.00

Plate 256



STRAIN PATH #2B
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.90 gm/cc
Moisture Content: 9.70 %
BOX #6, SAMPLE #5
A
B
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00


STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.91 gm/cc
Moisture Content: 6.58 %
BOX #2, SAMPLE #4
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200



STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.91 gm/cc
Moisture Content: 6.58 %
BOX #2, SAMPLE #4
A
B
-2.00
0.00
2.00
4.00
6.00
8.00
PRINCIPAL STRESS DIFFERENCE, MPA
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
MEAN NORMAL STRESS, MPA

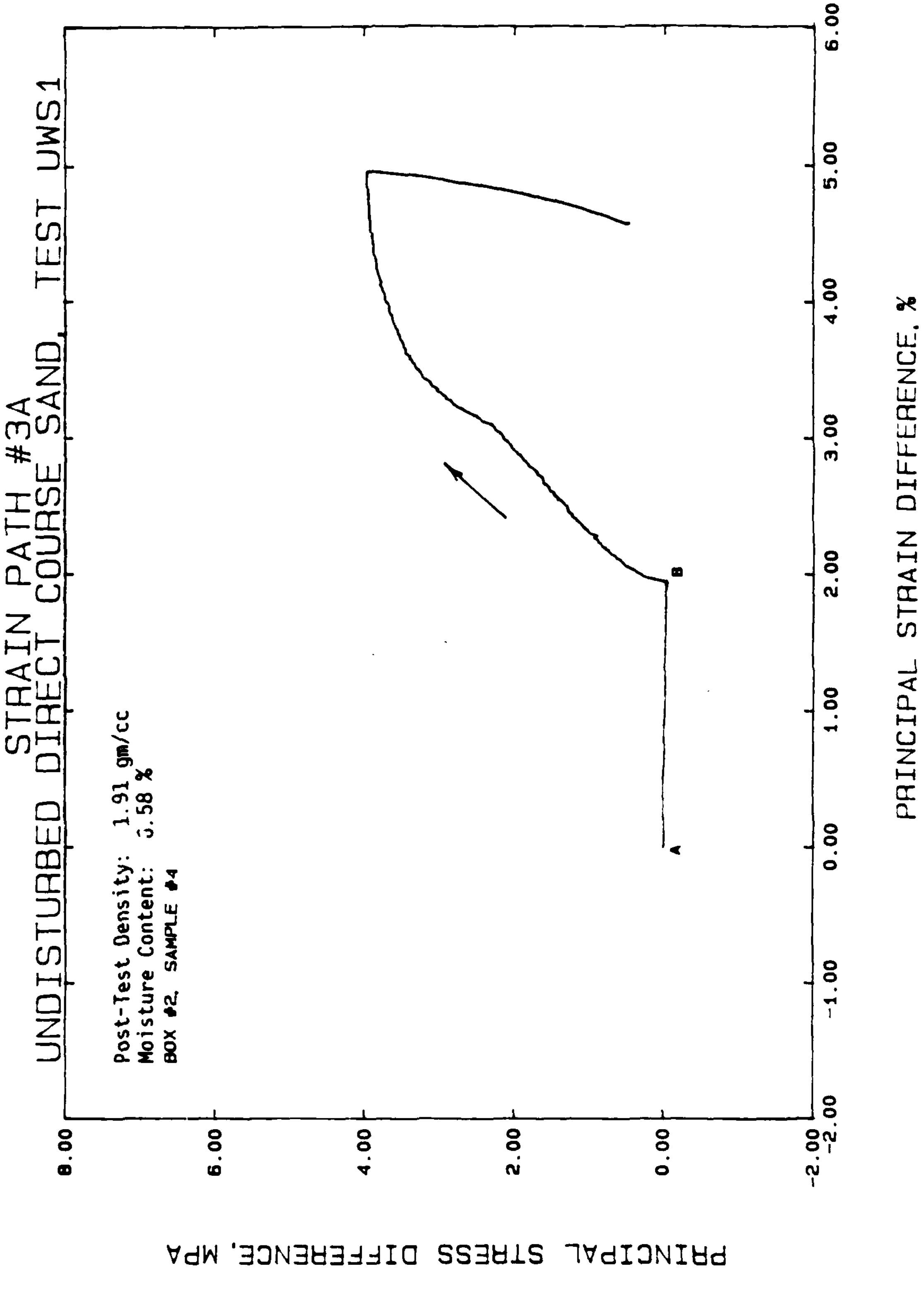
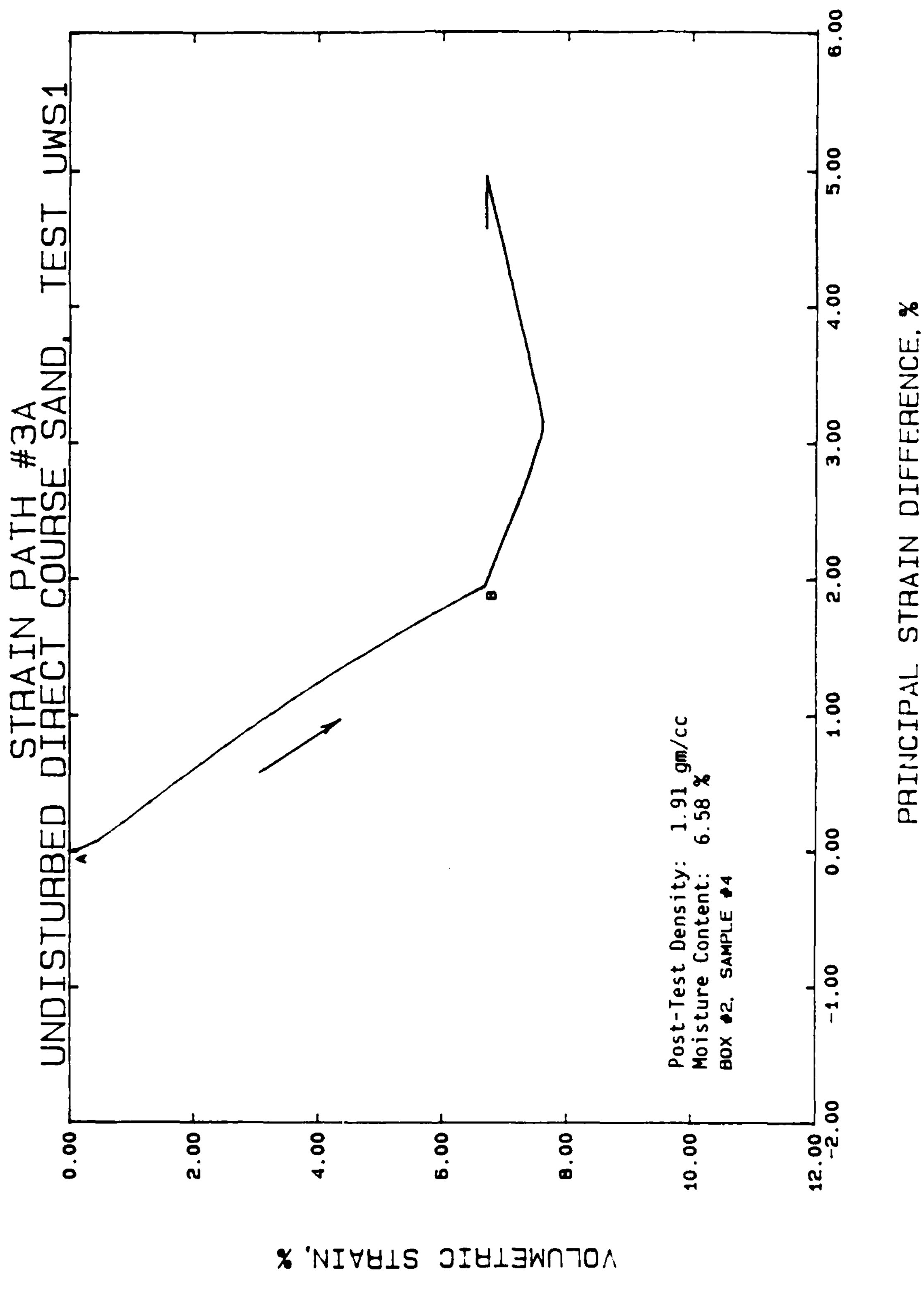
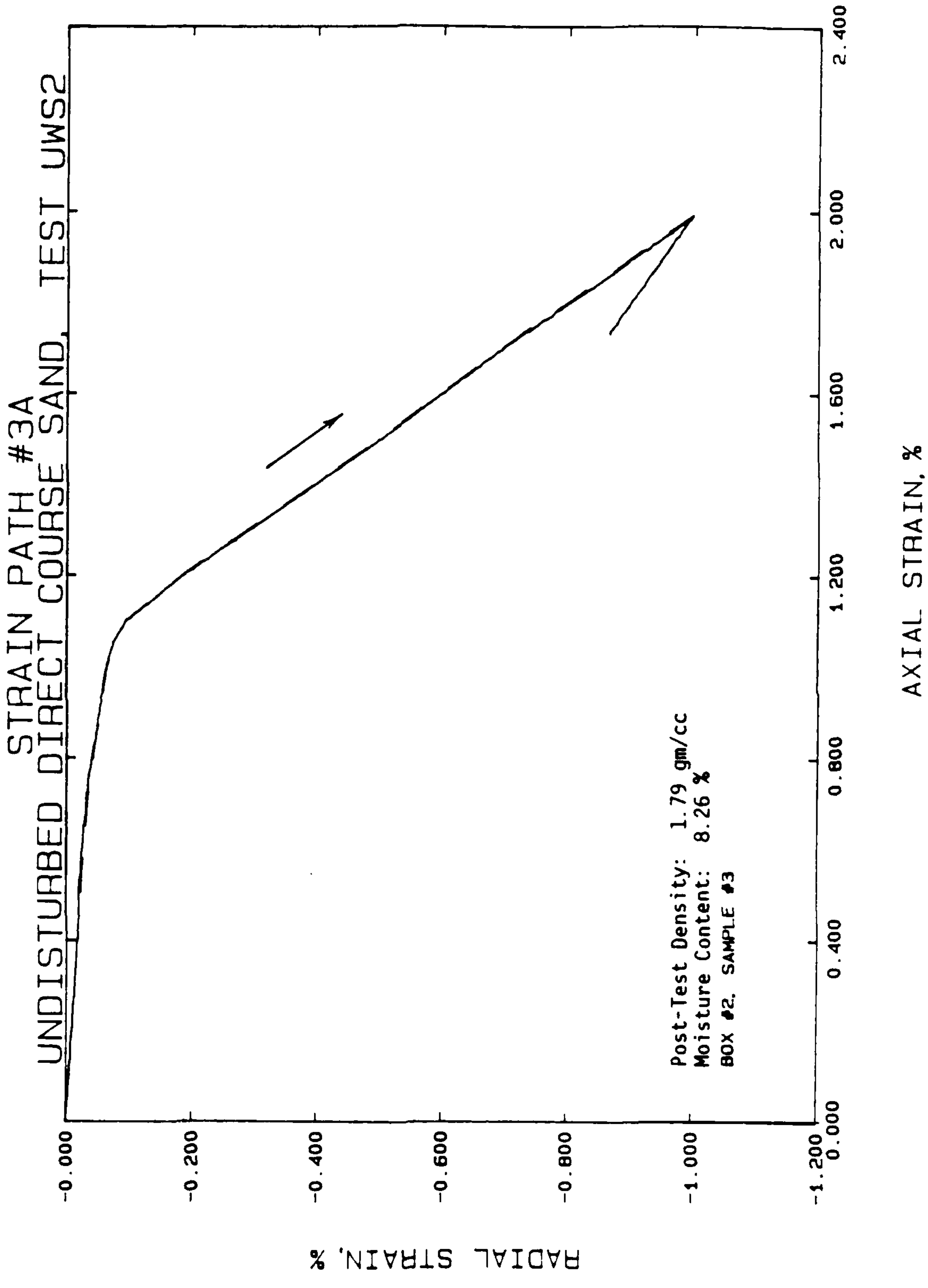

STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.91 gm/cc
Moisture Content: 3.58 %
BOX #2, SAMPLE #4
A
B
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRAIN DIFFERENCE, %
PRINCIPAL STRESS DIFFERENCE, MPA

Plate 260



STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.91 gm/cc
Moisture Content: 6.58 %
BOX #2, SAMPLE #4
A
B
VOLUMETRIC STRAIN, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
PRINCIPAL STRAIN DIFFERENCE, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00

Plate 261



STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS2
Post-Test Density: 1.79 gm/cc
Moisture Content: 8.26 %
BOX #2, SAMPLE #3
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200

Plate 262

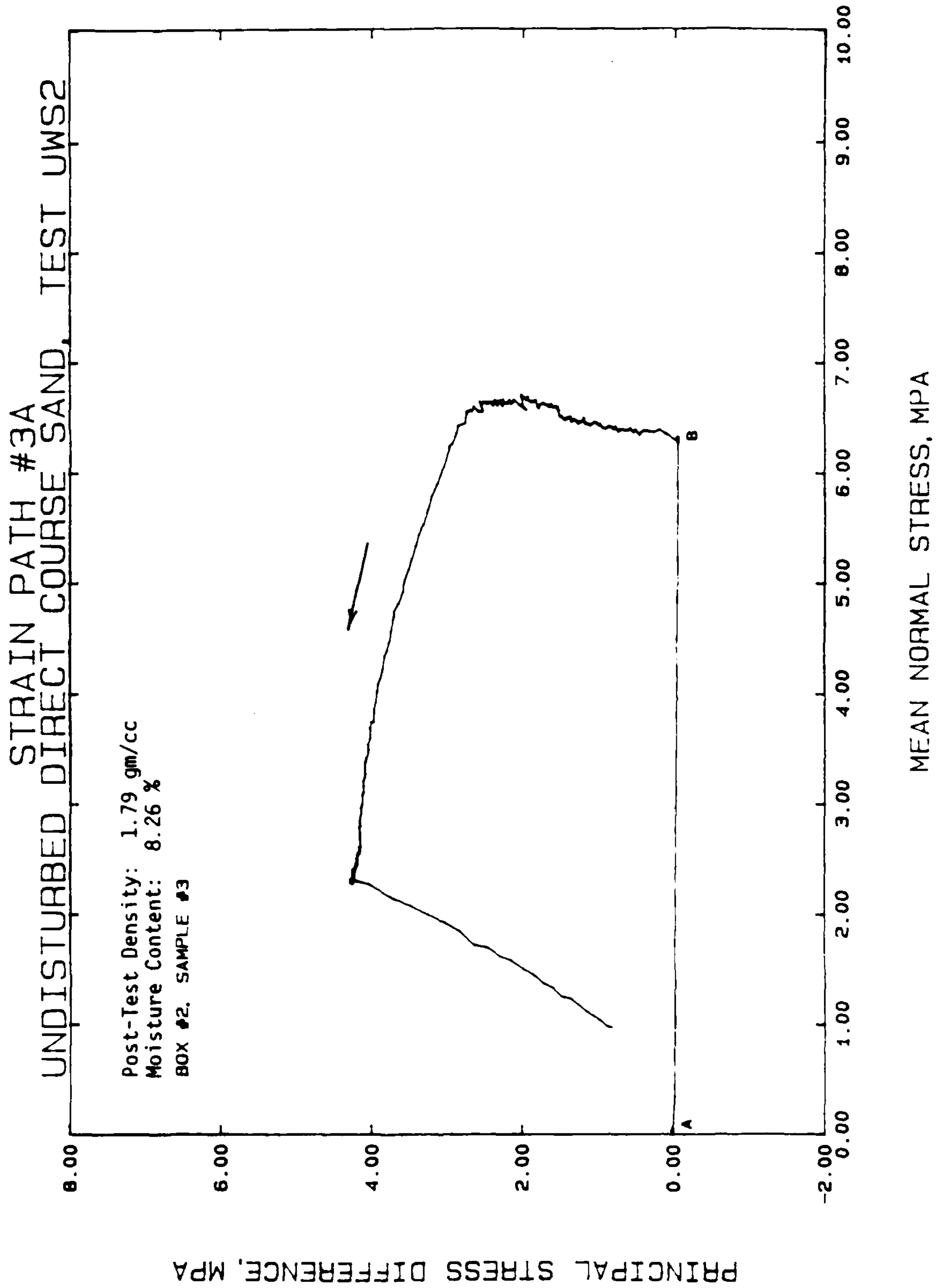
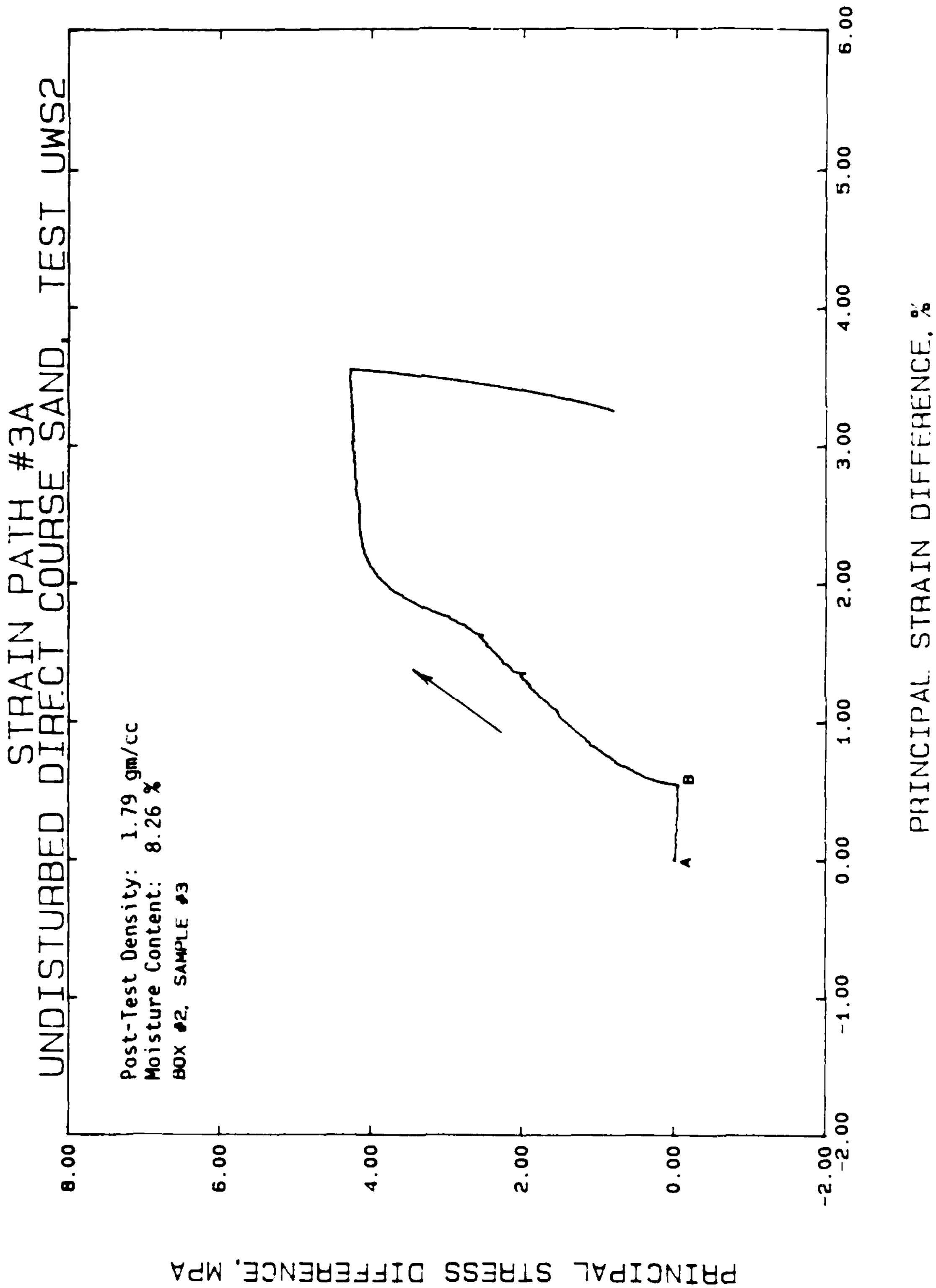
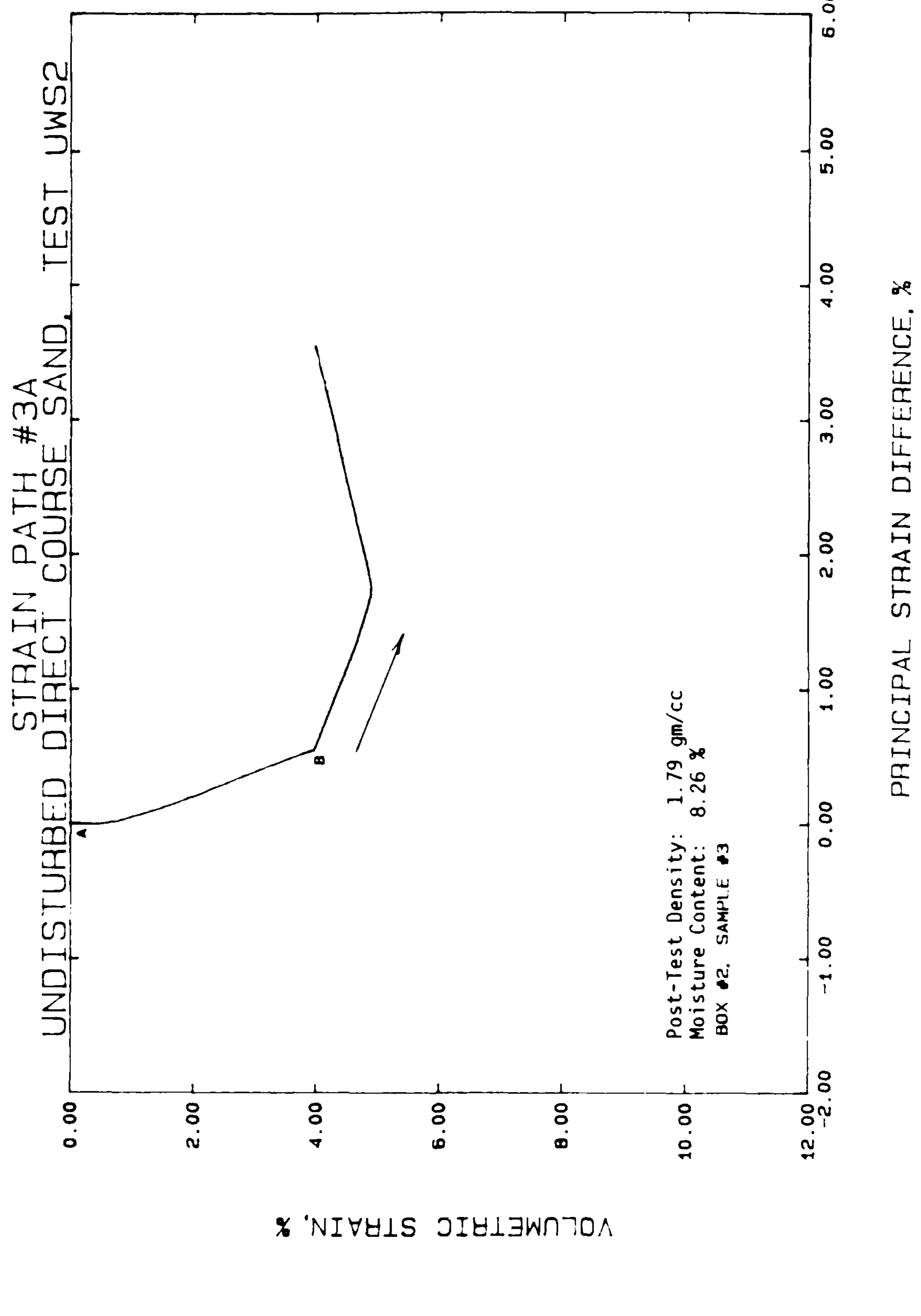

STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS2
Post-Test Density: 1.79 gm/cc
Moisture Content: 8.26 %
BOX #2, SAMPLE #3
A
B
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA

Plate 263


STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS2
Post-Test Density: 1.79 gm/cc
Moisture Content: 8.26 %
BOX #2, SAMPLE #3
A
B
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %


STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS2
Post-Test Density: 1.79 gm/cc
Moisture Content: 8.26 %
BOX #2, SAMPLE #3
A
B
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00

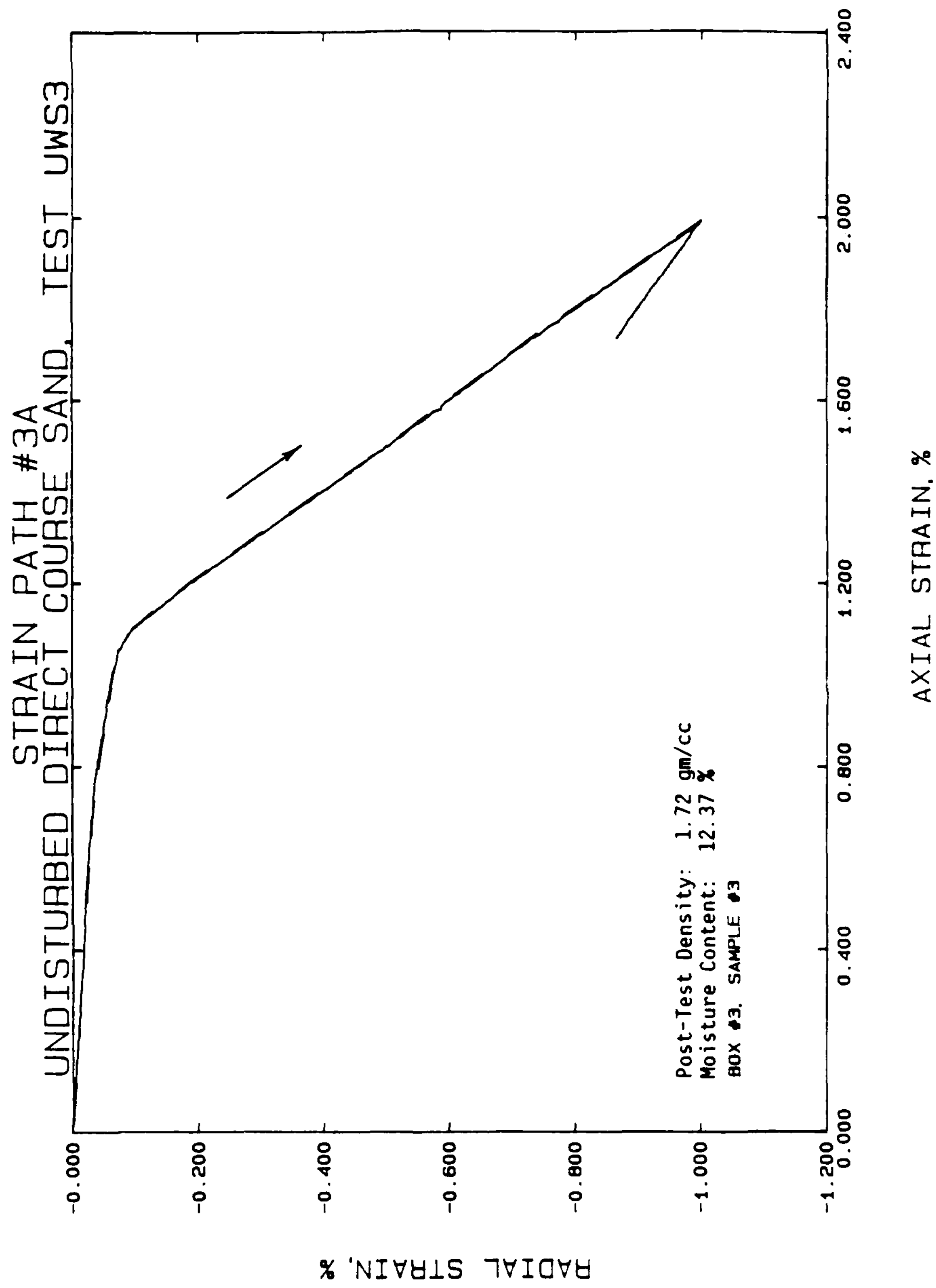
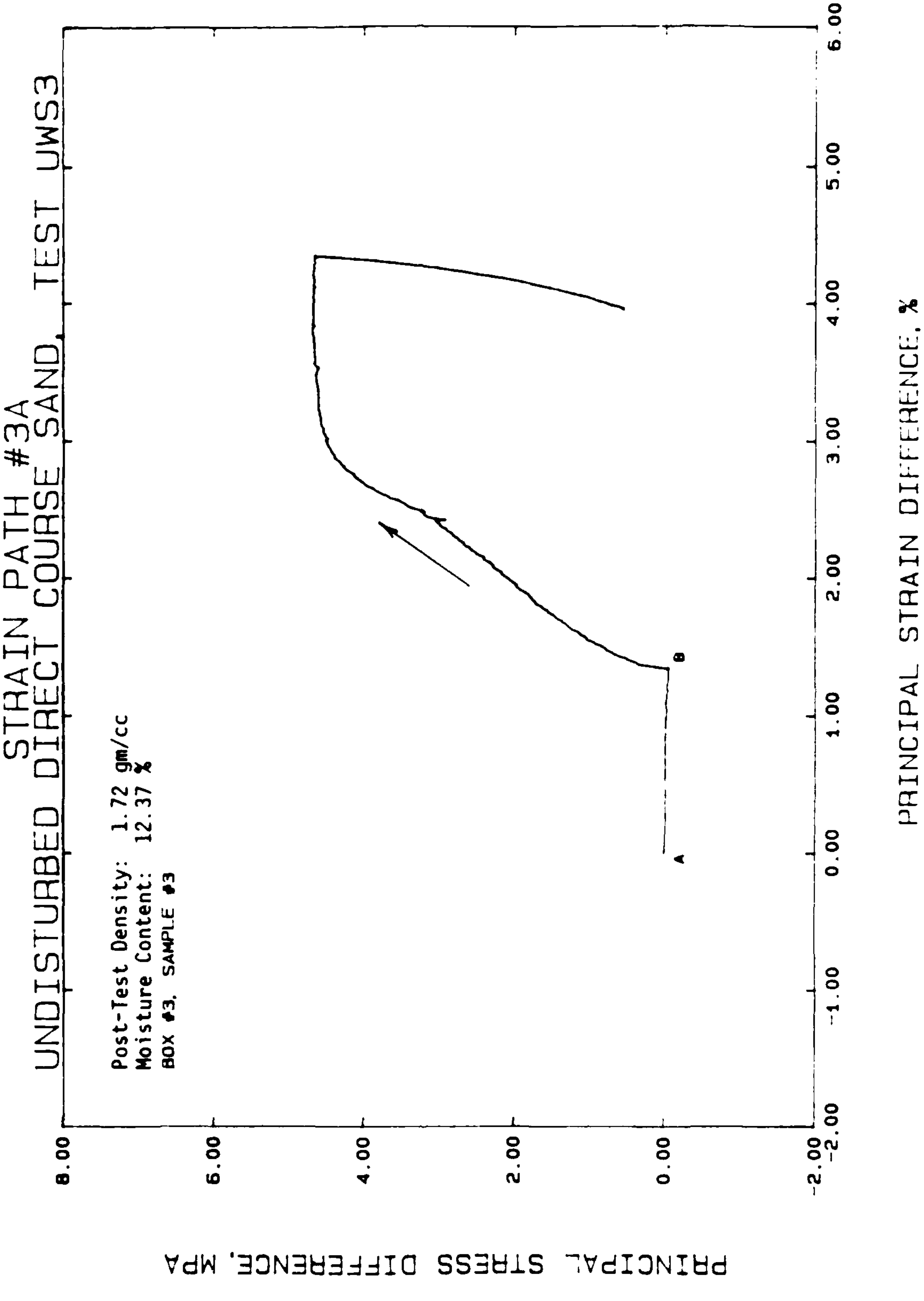

STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS3
Post-Test Density: 1.72 gm/cc
Moisture Content: 12.37 %
BOX #3, SAMPLE #3
AXIAL STRAIN, %
RADIAL STRAIN, %
0.000
0.400
0.800
1.200
1.600
2.000
2.400
-0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200

Plate 266



STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS3
Post-Test Density: 1.72 gm/cc
Moisture Content: 12.37 %
BOX #3, SAMPLE #3
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %
8.00
6.00
4.00
2.00
0.00
-2.00
-1.00
1.00
3.00
5.00

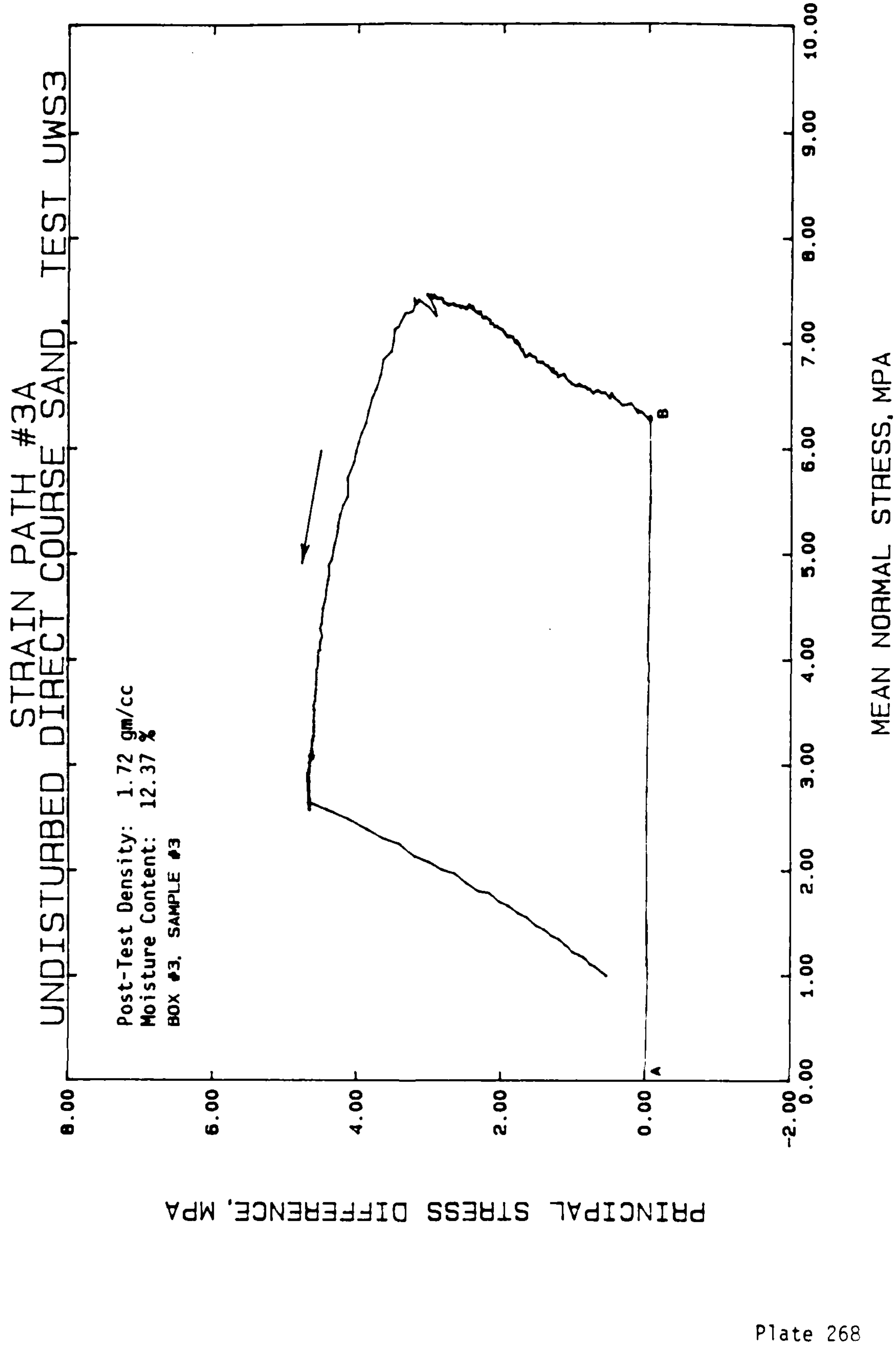
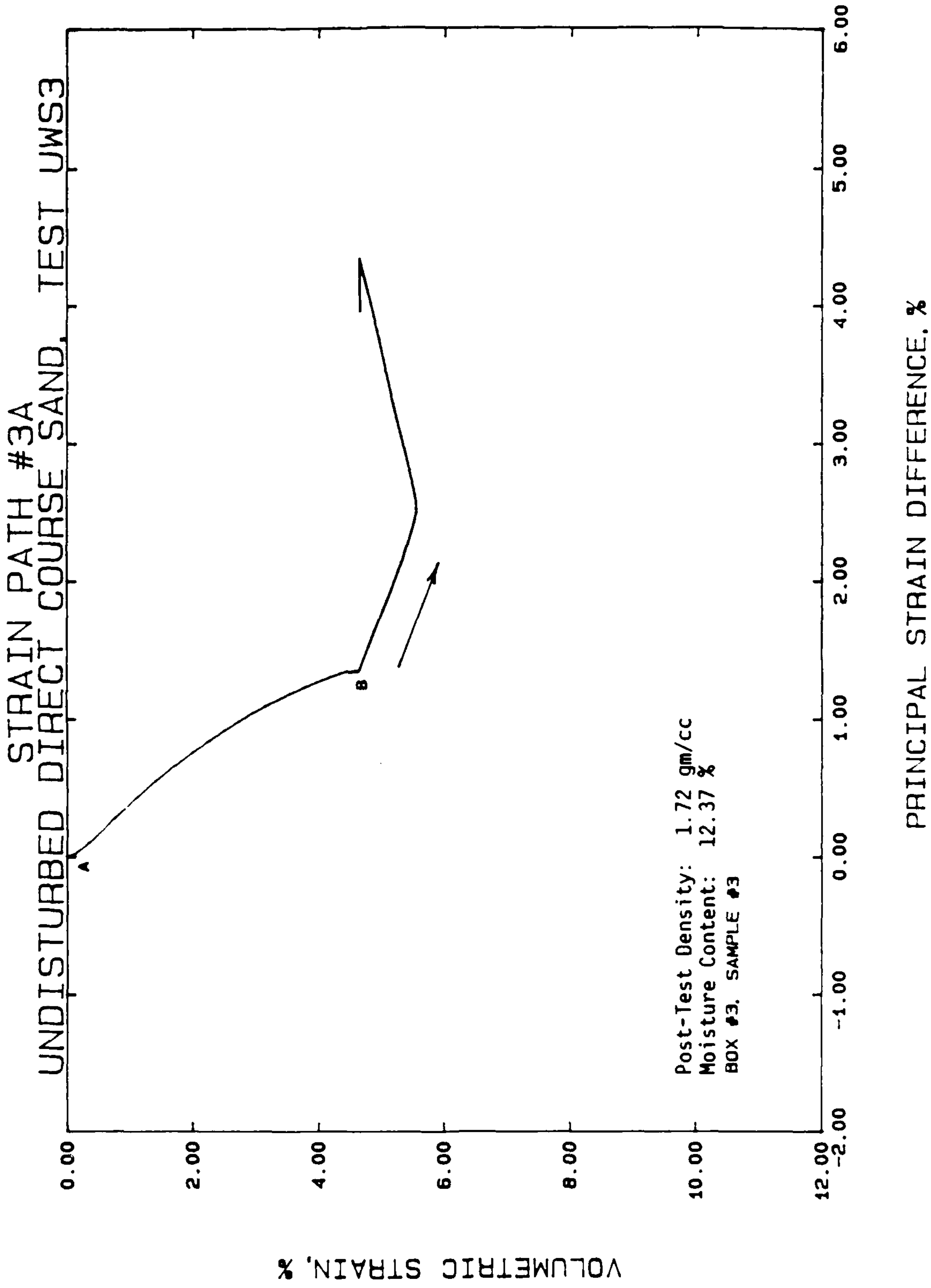

STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS3
Post-Test Density: 1.72 gm/cc
Moisture Content: 12.37 %
BOX #3, SAMPLE #3
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
MEAN NORMAL STRESS, MPA
8.00
6.00
4.00
2.00
0.00
-2.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00

Plate 268



STRAIN PATH #3A
UNDISTURBED DIRECT COURSE SAND, TEST UWS3
Post-Test Density: 1.72 gm/cc
Moisture Content: 12.37 %
BOX #3, SAMPLE #3
A
B
PRINCIPAL STRAIN DIFFERENCE, %
VOLUMETRIC STRAIN, %
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00

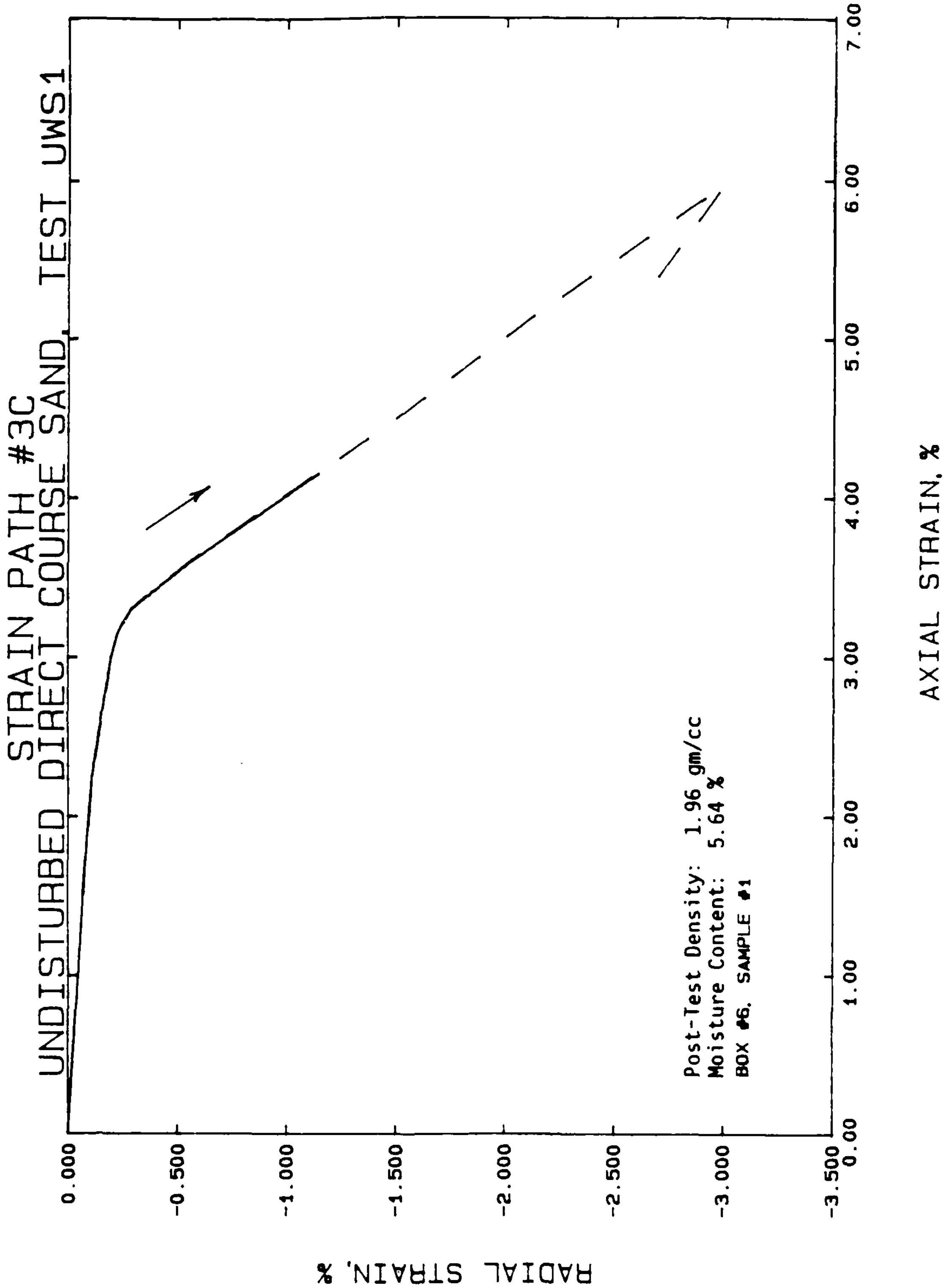

STRAIN PATH #3C
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.96 gm/cc
Moisture Content: 5.64 %
BOX #6, SAMPLE #1
AXIAL STRAIN, %
RADIAL STRAIN, %
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
-3.000
-3.500

Plate 270

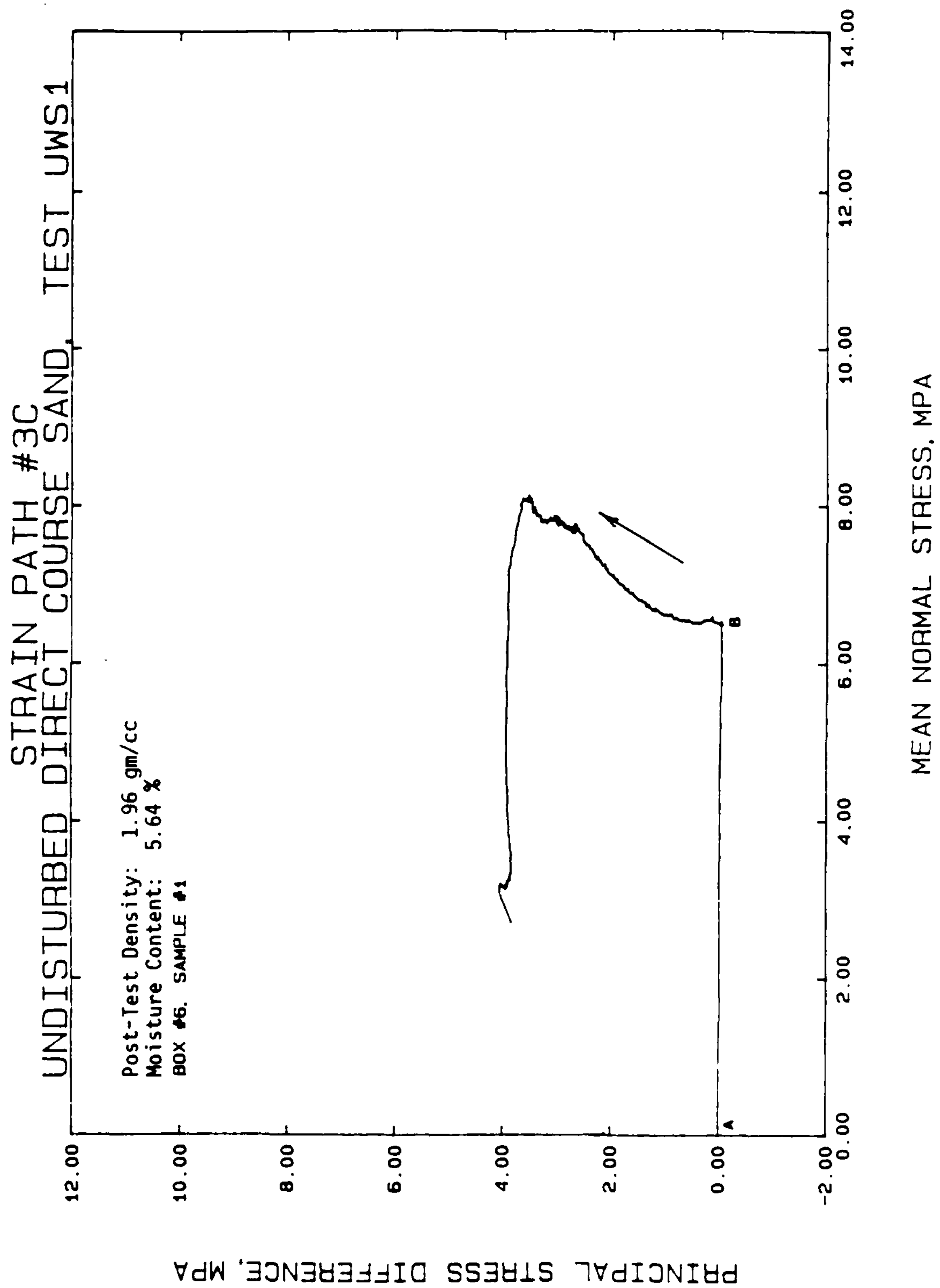
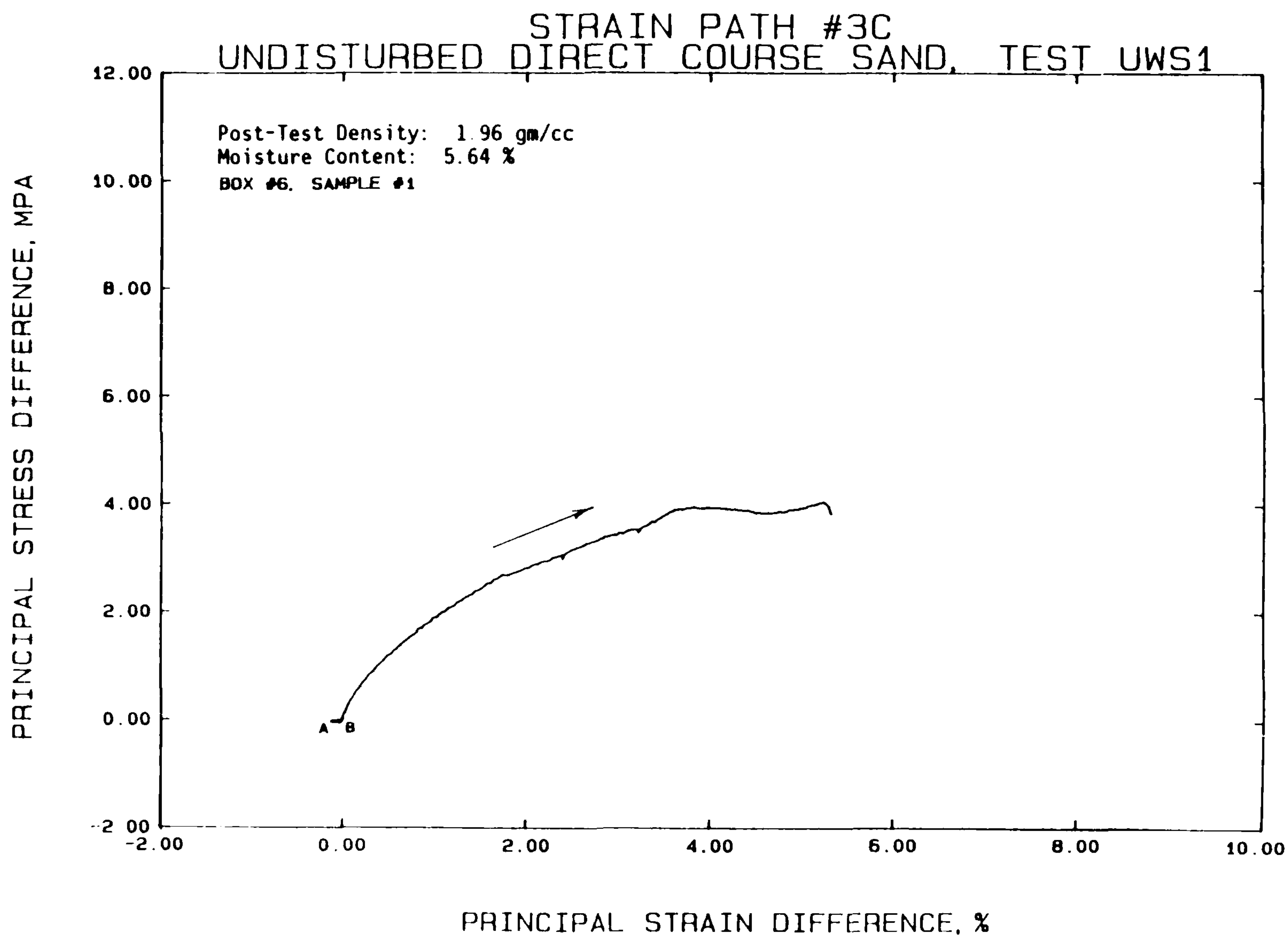
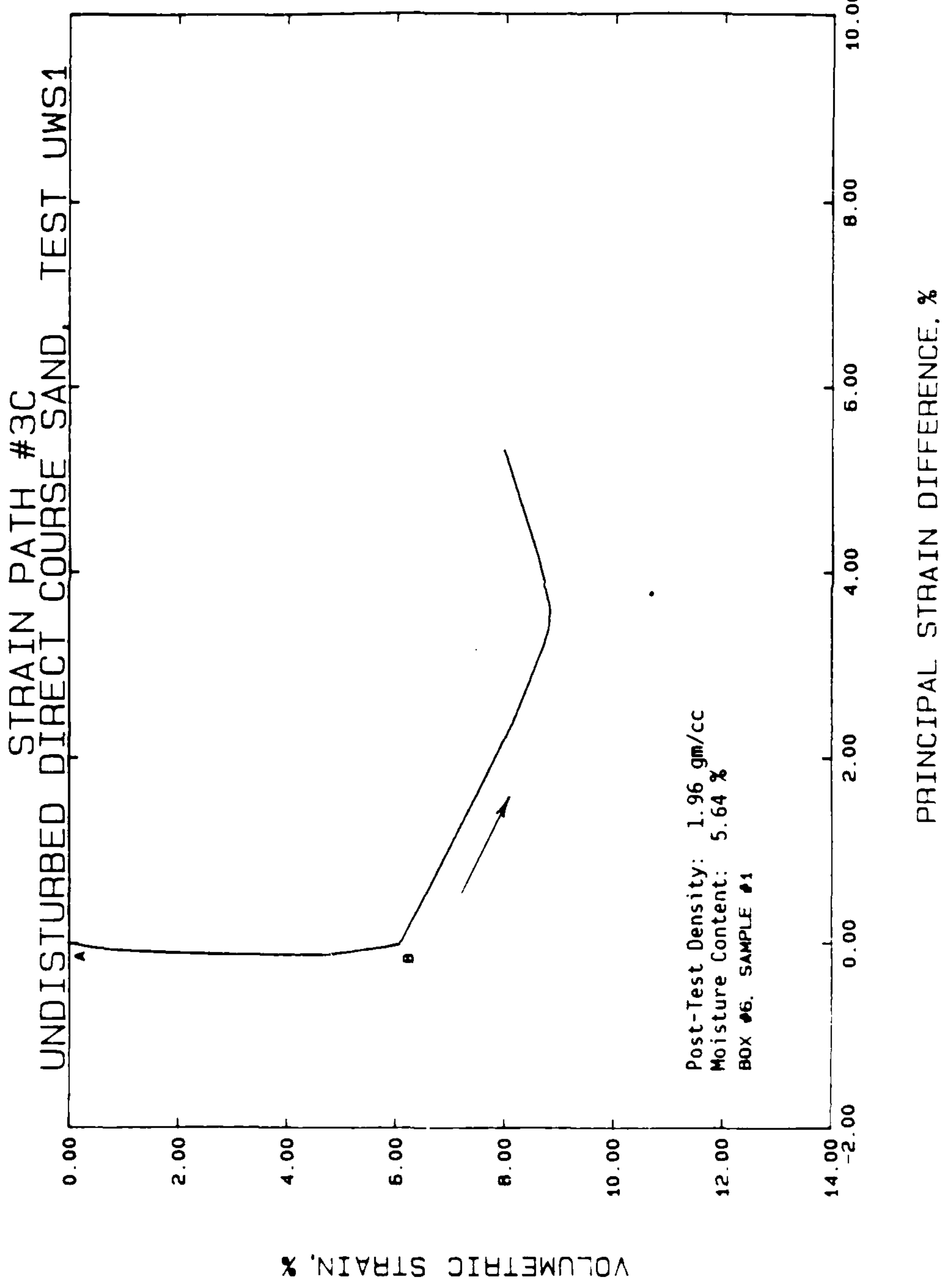

STRAIN PATH #3C
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.96 gm/cc
Moisture Content: 5.64 %
BOX #6, SAMPLE #1
A
B
PRINCIPAL STRESS DIFFERENCE, MPA
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
MEAN NORMAL STRESS, MPA
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Plate 271


STRAIN PATH #3C
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
Post-Test Density: 1.96 gm/cc
Moisture Content: 5.64 %
BOX #6, SAMPLE #1
A
B
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
PRINCIPAL STRESS DIFFERENCE, MPA
PRINCIPAL STRAIN DIFFERENCE, %



STRAIN PATH #3C
UNDISTURBED DIRECT COURSE SAND, TEST UWS1
VOLUMETRIC STRAIN, %
PRINCIPAL STRAIN DIFFERENCE, %
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
A
B
Post-Test Density: 1.96 gm/cc
Moisture Content: 5.64 %
BOX #6, SAMPLE #1

Plate 273

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

DEFENSE INTELLIGENCE AGENCY
ATTN: RTS-2B

DEFENSE NUCLEAR AGENCY
ATTN: SPSD M REED
2 CYS ATTN: SPWE M PELKEY
4 CYS ATTN: TITL

DEFENSE TECHNICAL INFORMATION CENTER
12CYS ATTN: DD

DEPARTMENT OF THE ARMY

U S ARMY ENGR WATERWAYS EXPER STATION
2 CYS ATTN: J JACKSON, WESSD
ATTN: J ZELASKO, WESSD-R
ATTN: TECHNICAL LIBRARY
ATTN: WESSE (J K INGRAM)

U S ARMY MISSILE COMMAND
ATTN: AMSMI-RD-CS-R (DOCS)

DEPARTMENT OF THE NAVY

NAVAL FACILITIES ENGINEERING COMMAND
ATTN: CODE 04B

DEPARTMENT OF THE AIR FORCE

AIR FORCE WEAPONS LABORATORY
ATTN: NTED J THOMAS
ATTN: NTED R HENNY

DEPARTMENT OF DEFENSE CONTRACTORS

APPLIED RESEARCH ASSOCIATES, INC
ATTN: N HIGGINS

APPLIED RESEARCH ASSOCIATES, INC
ATTN: S BLOUIN

APPLIED RESEARCH ASSOCIATES, INC
ATTN: J D'ARCY

BDM CORP
ATTN: F LEECH

CALIFORNIA RESEARCH & TECHNOLOGY, INC
ATTN: LIBRARY

KAMAN SCIENCES CORP
ATTN: LIBRARY/B KINSLOW

KAMAN TEMPO
ATTN: DASIAC

KAMAN TEMPO
ATTN: DASIAC

PACIFIC-SIERRA RESEARCH CORP
ATTN: H BRODE, CHAIRMAN SAGE

R & D ASSOCIATES
ATTN: J LEWIS
ATTN: TECH INFO CENTER

S-CUBED
ATTN: LIBRARY

S-CUBED
ATTN: B L RISTVET

SCIENCE APPLICATIONS INTL CORP
ATTN: TECHNICAL LIBRARY

SRI INTERNATIONAL
ATTN: D KEOUGH

TERRA TEK, INC
2 CYS ATTN: J WANGSGARD
2 CYS ATTN: R SMITH
ATTN: S GREEN
2 CYS ATTN: T BORSCHEL
2 CYS ATTN: W KLAUBER

TRW INC
ATTN: TECH INFO CTR,DOC ACQ

WEIDLINGER ASSOC
ATTN: J ISENBERG

WEIDLINGER ASSOC, CONSULTING ENGRG
ATTN: M BARON

END

FILMED

MARCH, 1988

DTIC